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Regional Sediment Management (RSM) Program

Hawaii Regional Sediment Management Needs Assessment

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Abstract

Regional Sediment Management (RSM) refers to the effective use of littoral, estuarine, and riverine sediment resources in an environmentally sensitive and economically efficient manner. RSM was officially implemented at the U.S. Army Engineer District, Honolulu, Hawaii (POH), in February 2004. The overall POH RSM strategy is to investigate RSM opportunities along all coastal regions in Hawaii. Opportunities to implement RSM activities are documented and prioritized by island based on input from the Hawaii RSM Project Delivery Team (PDT) consisting of POH staff; the State of Hawaii Department of Land and Natural Resources, Office of Conservation and Coastal Lands; County staff; and various stakeholders. The U.S. Geological Survey (USGS) also recognizes that beach erosion is a chronic problem along most open-ocean shores. USGS has contracted with the University of Hawaii (UH) at Manoa, Coastal Geology Group (CGG), to conduct an assessment of shoreline change on three of the main Hawaiian Islands (Kauai, Oahu, and Maui). Because of the inherent critical interest of these three coastal sediment aligned organizations (USACE, USGS, and UH CGG), conclusions by these agencies regarding sedimentation along the coastlines of the Hawaiian Islands of interest are incorporated into this document. Permission of USGS to reproduce verbatim pertinent text, tables, and figures regarding Kauai, Oahu, and Maui is acknowledged with appreciation. Pertinent sections from the UH CGG website pertaining to the Island of Hawaii are also extracted verbatim by permission which also is acknowledged with appreciation. Shoreline change rates were calculated from long-term and short-term shoreline data. A minimum of three historical shoreline positions was required when calculating the shoreline change rate. An island-by-island prioritization of RSM initiatives has been conducted by the Hawaii RSM PDT, along with a strategy to maximize beneficial use opportunities.

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Preface

The studies reported herein were conducted as part of the U.S. Army Corps of Engineers (USACE) Regional Sediment Management (RSM) Program, under the RSM work unit "Regional Sediment Management Needs in Hawaii." Overall program management of the RSM is provided by Headquarters (HQ), USACE. The Coastal and Hydraulics Laboratory (CHL), U.S. Army Engineer Research and Development Center (ERDC), is responsible for technical and data management and support for HQUSACE review and technology transfer. The HQUSACE Program Monitor for the RSM program at the time of this study was James E. Walker, Chief, Navigation Branch, HQ. W. Jeff Lillycrop, CHL, was the ERDC Technical Director for Navigation. USACE RSM Program Manager during the conduct of this study was Linda S. Lillycrop (Linda.S.Lillycrop@usace.army.mil), Navigation Division (ND), Coastal Engineering Branch (CEB), CHL.

These studies were conducted under the general supervision of Dr. William D. Martin, Director, CHL, and Dr. Rose M. Kress, Chief, Navigation Division (ND), CHL, and under the direct supervision of Dr. Jeffrey P. Waters, Chief, Coastal Engineering Branch, (CEB), ND, CHL. Thomas D. Smith, Coastal Engineer, U.S. Army Engineer District, Honolulu, Hawaii (POH), was the Hawaii RSM principal investigator and technical point of contact for the USACE RSM program during the conduct of this study and the preparation of this report. Smith substantially prepared this report with manuscript technical review and edification by Linda S. Lillycrop.

Permission of the U.S. Geological Survey to reproduce verbatim pertinent text, figures, and tables from the USGS Open-File Report 2011-1051, *National Assessment of Shoreline Change: Historical Shoreline Change in the Hawaiian Islands*, is acknowledged with appreciation. This USGS report was prepared by Drs. Charles H. Fletcher, Bradley M. Romine, Ayesha S. Genz, Matther M. Barbee, Matthew Dyer, Tiffany R. Anderson, S. Chyn Lim, Sean Vitousek, and Christopher Bochicchio, Coastal Geology Group (CGG), School of Ocean and Earth Science and Technology, University of Hawaii (UH) at Manoa, Honolulu, Hawaii; and Dr. Bruce M. Richmond, Pacific Coastal and Marine Science Center, U.S. Geological

Survey (USGS), U.S. Department of the Interior, Santa Cruz, CA.
http://pubs.usgs.gov/of/2011/1051/pdf/ofr2011-1051_report_508_rev052512.pdf

Permission of the UH CGG to reproduce verbatim pertinent text and figures from the UH CGG internet website also is acknowledged with appreciation. Dr. Fletcher is Director, UH CGG.
http://www.soest.hawaii.edu/coasts/publications/hawaiiCoastline/hawaii.html

At the time of publication of this report, COL Jeffrey R. Eckstein was Commander and Executive Director of ERDC. Dr. Jeffery P. Holland was Director of ERDC.

Unit Conversion Factors

Multiply	By	To Obtain
cubic yards	0.7645549	cubic meters
feet	0.3048	meters
feet per year	0.3048	meters per year
inches	2.54	centimeters
pounds	0.453592	kilograms
miles	1.609344	kilometers
square yards	0.8361	square meters
tons	907.185	kilograms
°F	(°F – 32) × 5/9	°C

1 Introduction

Regional Sediment Management (RSM) Program

The U.S. Army Corps of Engineers (USACE) holds in trust and manages millions of acres of land and thousands of miles of waterways across the United States. USACE engineers and scientists develop new or enhance innovative technologies to make management decisions more accurate and efficient. Regional Sediment Management (RSM) concepts are significantly improving Corps mission accomplishments.

USACE Engineer Research and Development Center (ERDC) laboratories, along with partners from federal, state, and regional governments and academia, are pursuing rigorous regional investigations of sediment management to solve sediment related problems and improve the use of sediments. The RSM program is developing tools and knowledge necessary to understand the effects of sediment management actions at both local and regional scales. The program is developing methods and procedures to design regional sediment strategies. The efforts include all landscapes, from the upper watershed to the coastline. Major products resulting from the program include enhanced sediment budget tools that can be used to rapidly assess the regional impacts of up drift or upstream activities on down drift or downstream shorelines and channels; enhanced morphology modeling systems for coast and river systems that predict short- and long-term changes; and a framework for developing RSM strategies and implementing RSM in the field.

An RSM Demonstration Program documented that managing sediment on a regional scale can result in significant cost savings and increased benefits. Because regions may extend beyond the limits of USACE projects and, at times, beyond USACE District boundaries, many stakeholders with varied objectives and disciplines must become involved. Often, the USACE is the facilitating agency in developing regional sediment management strategies and may also be the agency with the technological skill and capability to assess the impact of alternative plans.

Focus areas within the RSM program are interrelated, producing information and capabilities that will be incorporated into RSM tools. RSM focus areas include (a) coastal morphology modeling and management, (b)

river-basin morphology modeling and management, (c) sediment processes and assessment, and (d) sediment management methods. Work areas fall into five categories: (a) basic sediment processes, (b) engineered solutions, (c) RSM tools, (d) informatics, and (e) technology transfer and insertion.

Purpose of the Hawaii Regional Sediment Management (RSM) Needs Assessment

This USACE ERDC Coastal and Hydraulics Laboratory (CHL) Technical Report (TR) provides a summary of the Regional Sediment Management (RSM) needs in the State of Hawaii. This TR identifies RSM opportunities within the State of Hawaii and prioritizes RSM activities by Island to optimize economic and environmental benefits.

Background

Regional Sediment Management (RSM) refers to the effective use of littoral, estuarine, and riverine sediment resources in an environmentally sensitive and economically efficient manner. RSM changes the focus of engineering activities from the local or project-specific scale to a broader scale that is defined by natural sediment processes. A prime motivator for the implementation of RSM principles and practices is the potential for reducing construction, maintenance, and operation costs of federally authorized projects. Implementing RSM principles also has the potential to positively impact multiple projects by enhancing their ability to realize authorized purposes and increase benefits.

RSM was officially implemented at the USACE Pacific Ocean Division, Honolulu District, Honolulu, Hawaii (POH), in February 2004. The overall POH RSM strategy is to investigate RSM opportunities along all regions in Hawaii. To date, Hawaii RSM has been instrumental in quantifying coastal processes and identifying sediment related issues in various regions on Island of Oahu (Mokapu Point to Makapuu Point and Diamond Head to Pearl Harbor), Island of Kauai (Poipu and Kekaha), and Island of Maui (Kahului and Kihei). In addition to identification and prioritization of future RSM efforts on these Islands, POH RSM will also investigate opportunities to conduct RSM activities on the Island of Hawaii.

The U.S. Department of the Interior, U.S. Geological Survey (USGS), also recognizes that beach erosion is a chronic problem along most open-ocean shores of the United States. USGS has contracted with the University of

Hawaii (UH) at Manoa, School of Ocean and Earth Science and Technology, Coastal Geology Group (CGG), to conduct an assessment of shoreline change on three of the main Hawaiian Islands (Kauai, Oahu, and Maui) (Fletcher et al. 2012). http://pubs.usgs.gov/of/2011/1051/pdf/ofr2011-1051_report_508_rev052512.pdf

The UH CGG is an affiliation of researchers, technicians, and graduate students within the Department of Geology and Geophysics that conducts investigations of shoreline change, carbonate geology, reef geology, sedimentology, and coastal morphodynamics. In the belief that many minds are better than one, UH CGG makes it a goal to assist one another in research projects. In so doing, UH CGG expands horizons, acquires new skills, and promotes more interesting research with a diversity of field and laboratory experiences. In general, UH CGG seeks to improve understanding of coastal change through time, requiring research investigation on a range of spatial and temporal scales. UH CGG provides a description of beaches on the Island of Hawaii (UH CGG 2012) at the website http://www.soest.hawaii.edu/coasts/publications/hawaiiCoastline/hawaii.html.

Because of the inherent critical interest of these three coastal sediment aligned organizations (USACE, USGS, and UH CGG), research conclusions by these agencies are incorporated into this TR, thus providing a comprehensive review of sedimentation along the coastlines of the Hawaiian Islands of interest. In this TR, pertinent sections of the USGS Open-File Report 2011-1051, *National Assessment of Shoreline Change: Historical Shoreline Change in the Hawaiian Islands* (Fletcher et al. 2012) pertaining to the Islands of Kauai, Oahu, and Maui are extracted verbatim by permission. Pertinent sections from the UH CGG website (UH CGG 2012) pertaining to the Island of Hawaii also are extracted verbatim by permission.

Approach

Federally authorized projects of interest on each of the main Hawaiian Islands shown in Figure 1 (Islands of Kauai, Oahu, Maui, and Hawaii) are identified, and the dredging history of each is presented (Table 1). Shoreline change for Islands of Kauai, Oahu, and Maui are presented as quantified by the USGS (Fletcher et al. 2012). Shoreline change rates were calculated from long-term and short-term shoreline data. All available shorelines were used for long-term rate calculations, and post-World War II shorelines were

Figure 1. Hawaiian Islands showing existing Hawaii RSM regions.

Table 1. Summary of federally authorized navigation project dredging in Hawaii.

YEAR	ISLAND	PROJECT	VOLUME [cy]	COST [$]	UNIT COST [$/cy]
1990	HAWAII	HILO HBR	80,000	$286,855	$3.59
1977	HAWAII	HILO HBR	54,118	$104,130	$1.92
1973	HAWAII	KAWAIHAE DDH	25,000	$61,800	$2.47
1999	KAUAI	NAWILIWILI DDH	115,000	$894,960	$7.78
1990	KAUAI	NAWILIWILI DDH	343,500	$692,160	$2.02
1983	KAUAI	NAWILIWILI DDH	183,977	$1,314,426	$7.14
1977	KAUAI	NAWILIWILI DDH	120,917	$95,355	$0.79
1973	KAUAI	NAWILIWILI DDH	146,000		
1968	KAUAI	NAWILIWILI DDH	242,201	$75,710	$0.31
1999	KAUAI	PORT ALLEN DDH	21,000	$252,000	$12.00
1977	KAUAI	PORT ALLEN DDH	141,891	$189,540	$1.34
1973	KAUAI	PORT ALLEN DDH	107,000		
1968	KAUAI	PORT ALLEN DDH	165,978	$84,931	$0.51
2004	LANAI	MANELE SBH	9,000	$570,250	$63.36
1985	LANAI	MANELE SBH	2,000	$435,357	$217.68
1999	MAUI	KAHULUI DDH	91,000	$825,120	$9.07
1990	MAUI	KAHULUI DDH	73,700	$425,876	$5.78
1977	MAUI	KAHULUI DDH	24,329	$41,925	$1.72
1973	MOLOKAI	KAUNAKAKAI HBR	51,000	$240,649	$4.72
1999	OAHU	BARBERS PT HBR	91,000	$1,212,480	$13.32
2009	OAHU	HALEIWA SBH	6,500	$1,000,000	$153.85
1999	OAHU	HALEIWA SBH	4,500	$1,000,000	$222.22
1999	OAHU	HONOLULU HBR	154,000	$1,316,800	$8.55
1990	OAHU	HONOLULU HBR	135,000	$498,520	$3.69
1983	OAHU	HONOLULU HBR	212,000		
1981	OAHU	HONOLULU HBR	1,000,000		
1977	OAHU	HONOLULU HBR	456,923	$445,672	$0.98
1972	OAHU	HONOLULU HBR	188,000		
1968	OAHU	HONOLULU HBR	122,693	$66,004	$0.54
2009	OAHU	WAIANAE SBH	2,000	$494,000	$247.00

used for short-term rate calculations. A minimum of three historical shoreline positions was required when calculating a shoreline change rate with the technique employed by the USGS. Figures from Fletcher et al. (2012) graphically depicting shoreline change by sub-region for each of these three islands are reproduced by permission. A description of the beaches on the Island of Hawaii as developed by UH CGG (2012) also is reproduced by permission.

Opportunities to implement RSM activities are documented and prioritized by island based on input from the Hawaii RSM Project Delivery Team (PDT). The PDT consists of POH staff; the State of Hawaii Department of Land and Natural Resources, Office of Conservation and Coastal Lands; County staff; and various stakeholders.

2 Island of Kauai

Federally authorized projects on the Island of Kauai that could potentially benefit from implementation of RSM principles and practices are shown in Figure 2. Areas in Figure 2 with the sandcastle icon represent potential sediment sources while areas identified with the shovel icon are experiencing shoreline recession. A portion of the Kauai shoreline consists of steep sea cliffs with little to no sediment resources. Other areas of the island are virtually undeveloped or do not offer any RSM opportunities. These areas have been designated as off limits and are identified by the strike-through icon.

Figure 2. Locations of federally authorized navigation projects (stars) and shore protection projects (yellow triangles) on Island of Kauai that could benefit from RSM activities.

The federally authorized projects of interest on Island of Kauai include (a) Kikiaola Shallow Draft Harbor, (b) Port Allen Deep Draft Harbor, (c) Nawiliwili Deep Draft Harbor, (d) Nawiliwili Small Boat Harbor, (e) Kapaa Shore Protection Project, and (f) Kekaha Shore Protection Project.

Dredging History

Nawiliwili Deep Draft Harbor has been dredged six times over the last 50 years (yr), and Port Allen Deep Draft Harbor has been dredged four times over the same time period (Table 2). Approximately 1,300,000 cubic yards (cy) were dredged from Nawiliwili Deep Draft Harbor at an annual rate of 30,000 cy per year (cy/yr). At Port Allen Deep Draft Harbor, approximately 1,800,000 cy have been dredged at an annual rate of 40,000 cy/yr. The quality of this material is unknown, but the majority has either gone offshore or to upland sites. Kikiaola Shallow Draft Harbor was dredged as part of federal modifications to the project in 2009. The material was not beach quality and was placed as landfill cover. Nawiliwili Small Boat Harbor has not needed any maintenance dredging in recent history. The largest and smallest unit costs for federal navigation project dredging on Kauai were $0.31/cy in 1968 and $7.78/cy in 1991, both at Nawiliwili Deep Draft Harbor.

Table 2. Summary of federally authorized navigation project dredging on Island of Kauai.

YEAR	ISLAND	PROJECT	VOLUME [cy]	COST [$]	UNIT COST [$/cy]
1999	KAUAI	NAWILIWILI DDH	115,000	$894,960	$7.78
1990	KAUAI	NAWILIWILI DDH	343,500	$692,160	$2.02
1983	KAUAI	NAWILIWILI DDH	183,977	$1,314,426	$7.14
1977	KAUAI	NAWILIWILI DDH	120,917	$95,355	$0.79
1973	KAUAI	NAWILIWILI DDH	146,000		
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1977	KAUAI	PORT ALLEN DDH	141,891	$189,540	$1.34
1973	KAUAI	PORT ALLEN DDH	107,000		
1968	KAUAI	PORT ALLEN DDH	165,978	$84,931	$0.51

Shore Protection

The Kapaa Shore Protection Project was completed in September 1976 at a cost of $189,700 (federal $132,800; non-federal $56,900). The project consists of the restoration of a 400 foot (ft) section of beach by placement of 6,000 cy of sand, rehabilitation of a 150 ft section of the Moikeha Groin, and construction of 70 ft of revetment along the north bank of Moikeha Canal. The local sponsor is the County of Kauai, Department of Public Works. The project has not been renourished since initial construction.

The Kekaha Beach Shore Protection Project protects approximately 5,900 ft of Kamualii Highway and consists of a rubble-mound revetment. The revetment has a crest elevation of +12 ft, 1–4 ton armor stone (two layers thick),

revetment toe (three stones wide), and a bedding layer (1–500 lb stone). The local sponsor is the State of Hawaii Department of Transportation (DOT).

Shoreline Change

The Island of Kauai has approximately 75 kilometers (km) of sandy beach. Figure 3 displays the four regions into which the USGS (Fletcher et al. 2012) divided the Island of Kauai to analyze shoreline change. Coastal processes in the North region are dominated by winter swell from the northwest through north, and trade wind waves from the northeast. The East region is typically impacted by trade wind waves while the South region is oriented in the direction of south swell that propagates out of the South Pacific Ocean from locations near and around New Zealand. The shoreline within the West region is oriented such that both South and North Pacific Ocean swell are common during the summer and winter months, respectively. Figures 4–7 provide the results of the USGS (Fletcher et al. 2012) shoreline change analysis for the Island of Kauai. Information provided in the figures includes shoreline position change rate (in meters) for long-term and short-term epics, the 95% confidence interval for each epic, and a map of the sub-regions. Maps also depict reaches of shoreline characterized as either sandy (yellow) or rocky (blue).

North Kauai Region

The backshore of Kauai's north coast is composed of rejuvenated volcanic basalt. The shoreline is characterized mostly by embayments and fringing reef systems. The shore is exposed to large North Pacific swell in winter and northeast trade wind waves throughout the year. The beaches tend to be steep and are composed of coarse-grained, calcareous sand (Fierstein and Fletcher 2004).[1]

From east to west, the North Kauai region includes the sub-regions of Moloaa, Kahili, Kauapea, Anini, Hanalei, Lumahai, and Haena Point (Figure 4). In the short term, the highest rate of shoreline recession (up to -1.0 meters per year (m/yr)) has occurred in the Kauapea sub-region. Sub-regions that have experienced shoreline advance on the order of 0.5 m/yr include Kahili, Hanalei, and Lumahai. The remainder of the region's shoreline has been relatively stable in the short term.

[1] This paragraph was extracted verbatim from Fletcher et al. 2012, by permission.

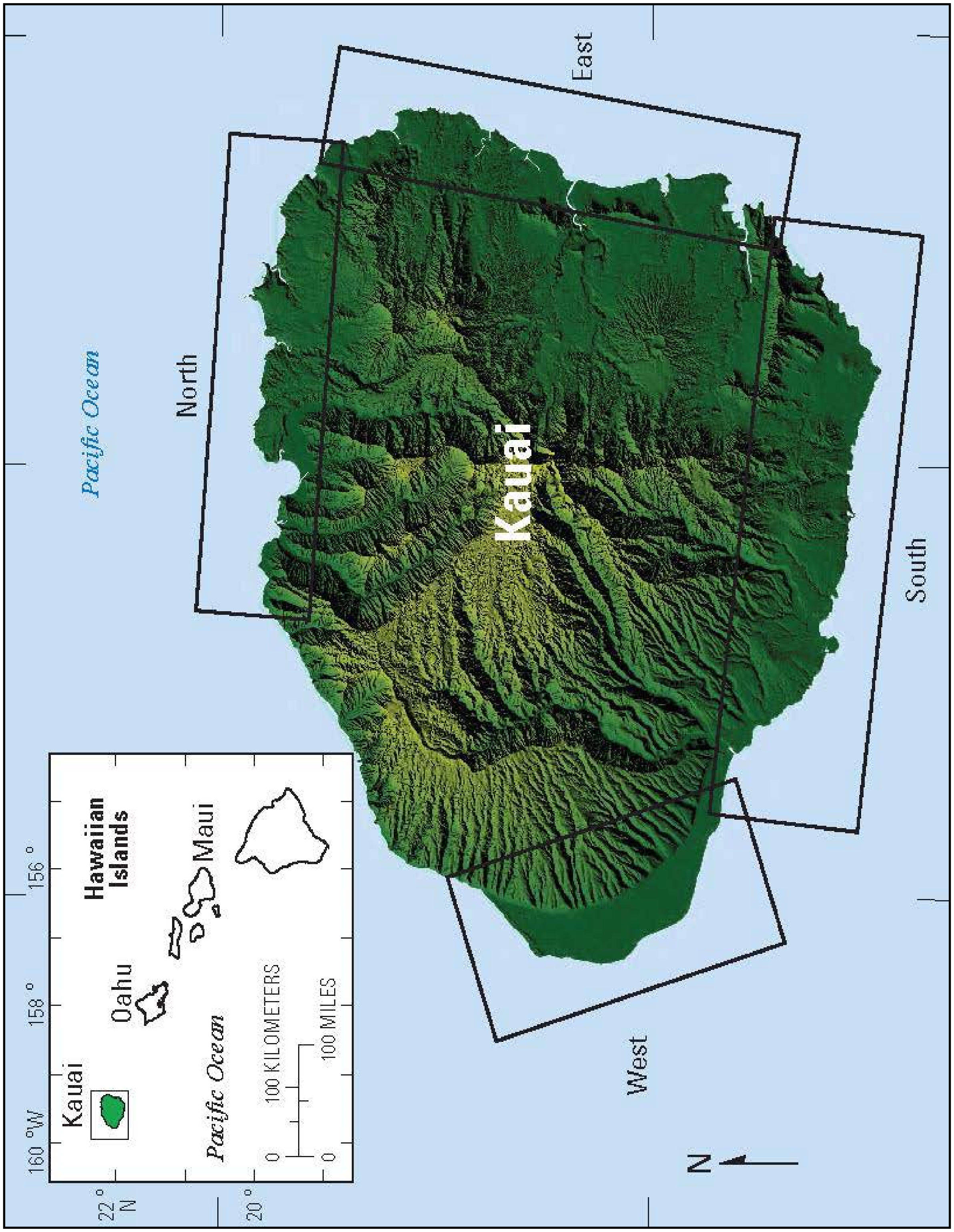


Figure 3. Four regions of Kauai (north, east, south, and west) (Figure 15 of Fletcher et al. 2012; by permission).

Figure 4. Long-term (all available years) and short-term (1940s to present) shoreline change rates, North Kauai (location shown in Figure 3) (Figure 16 of Fletcher et al. 2012; by permission).

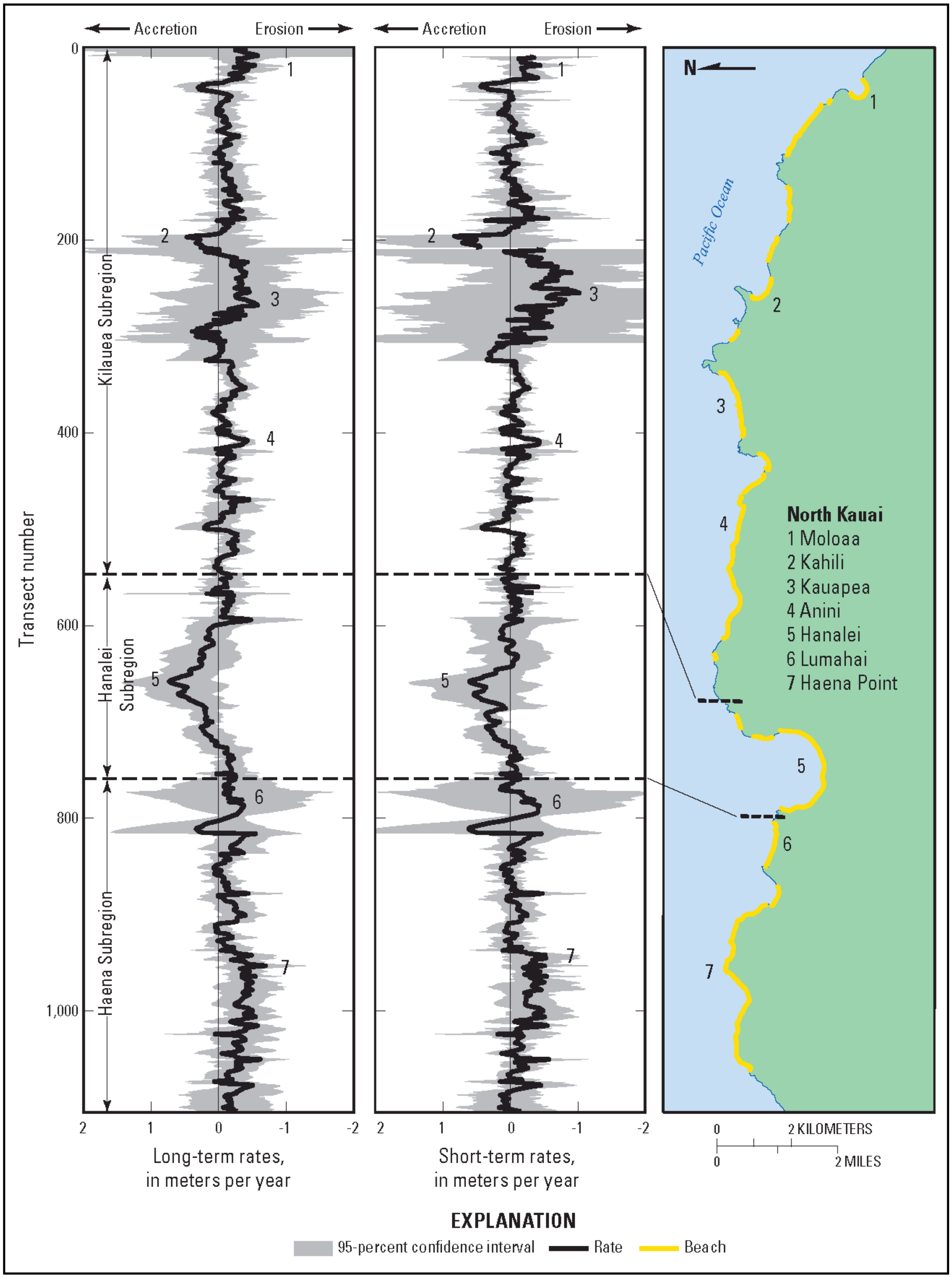


Figure 5. Long-term (all available years) and short-term (1940s to present) shoreline change rates, East Kauai (location shown in Figure 3) (Figure 17 of Fletcher et al. 2012; by permission).

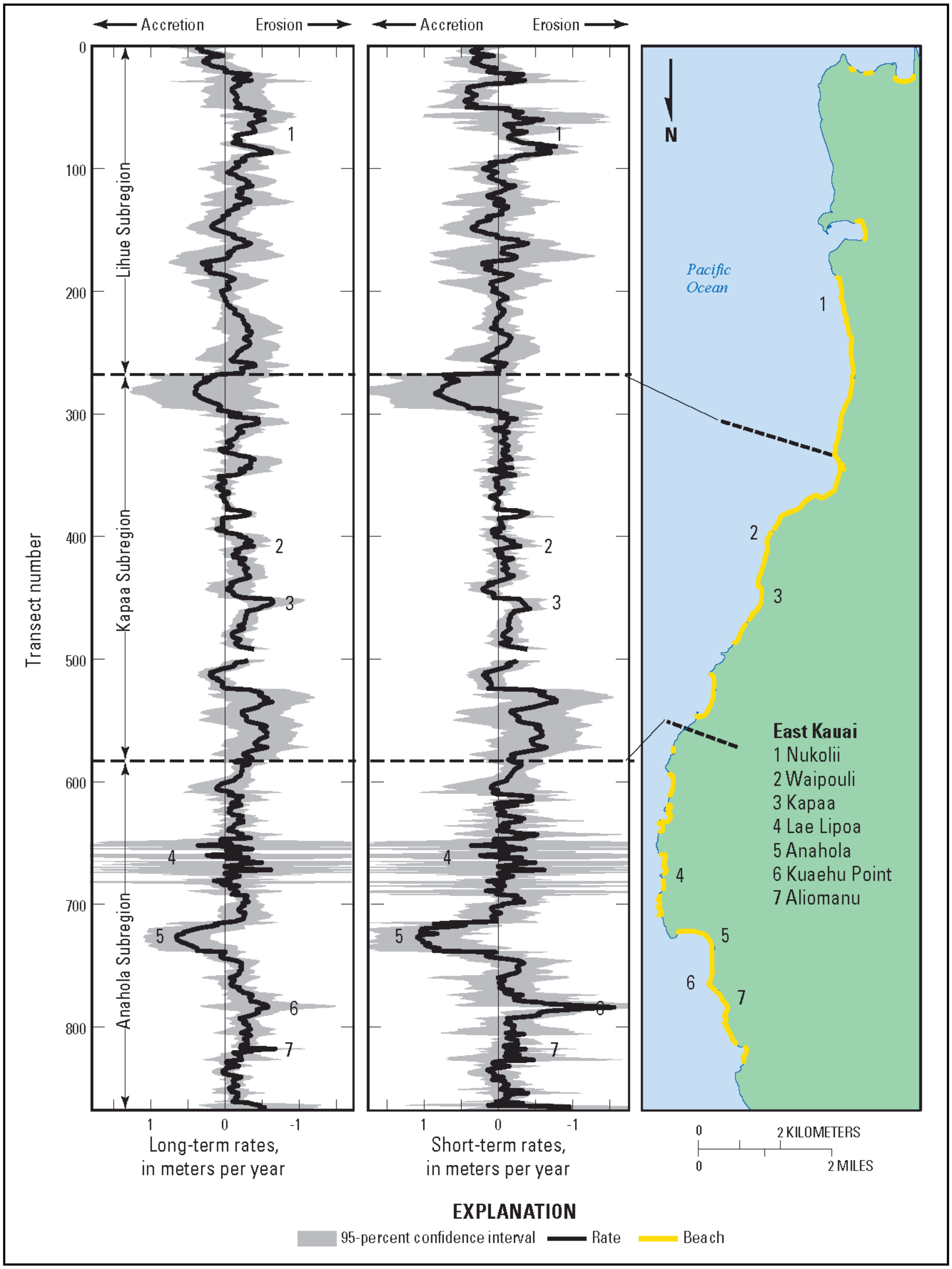


Figure 6. Long-term (all available years) and short-term (1940s to present) shoreline change rates, South Kauai (location shown in Figure 3) (Figure 19 of Fletcher et al. 2012; by permission).

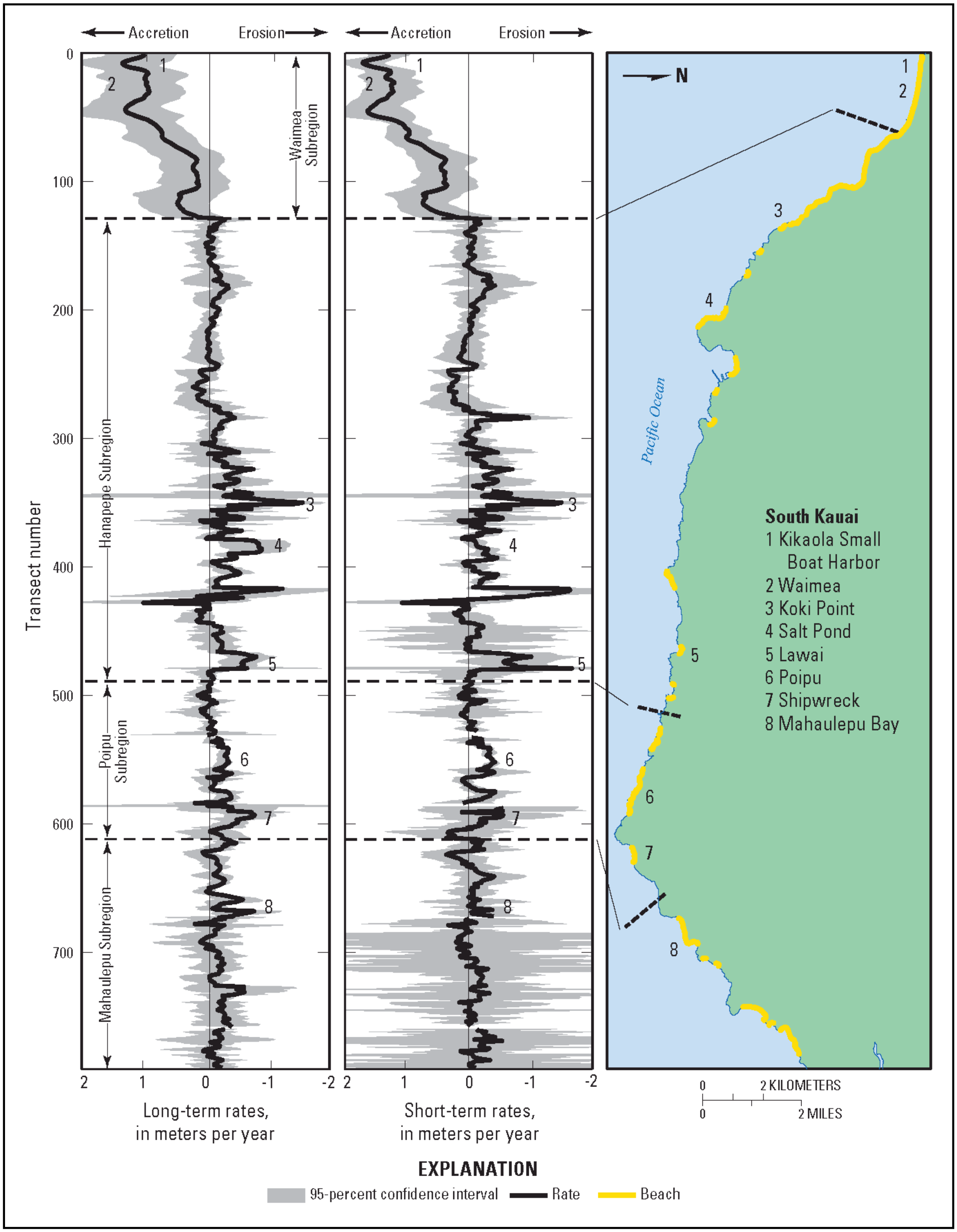
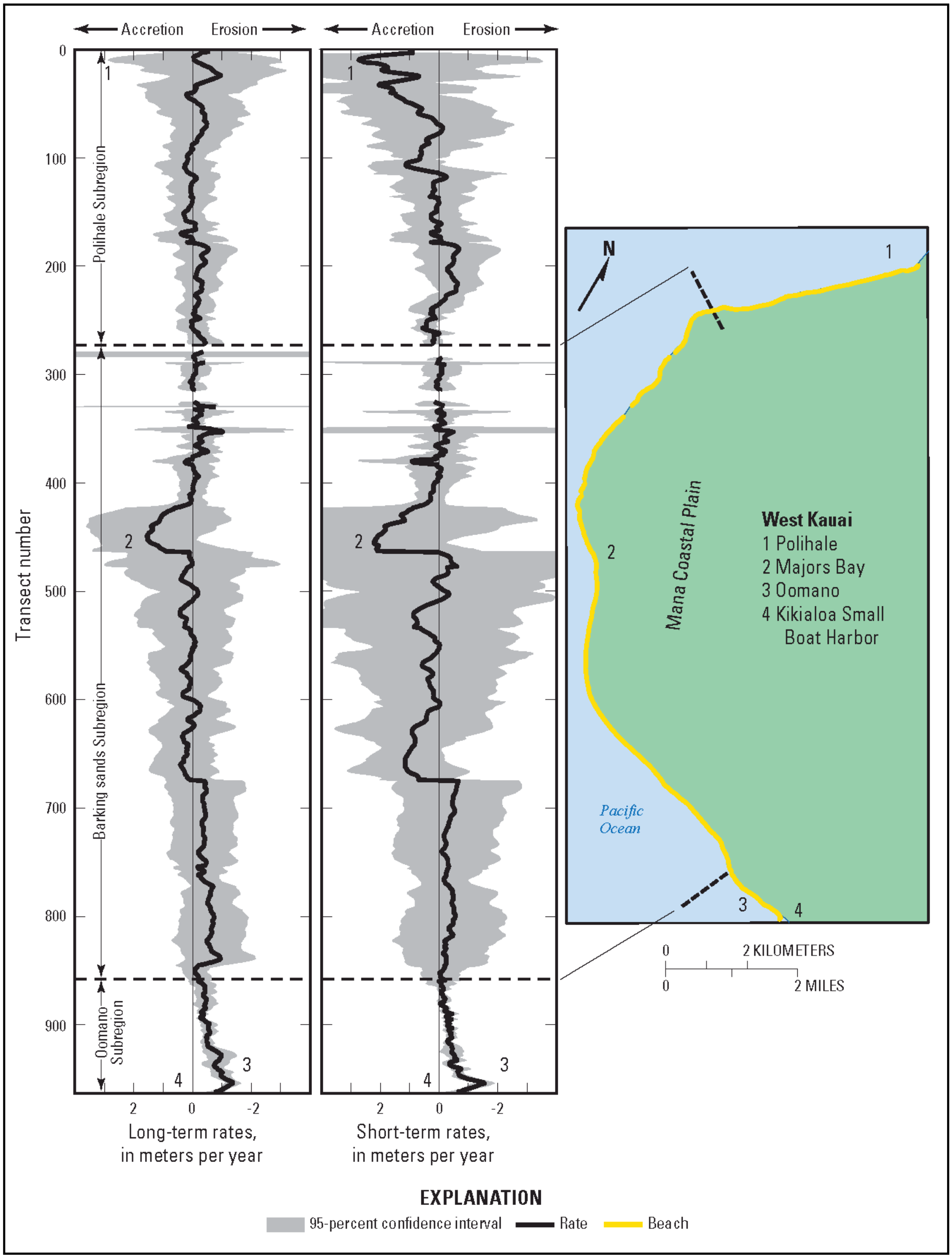


Figure 7. Long-term (all available years) and short-term (1940s to present) shoreline change rates, West Kauai (location shown in Figure 3) (Figure 21 of Fletcher et al. 2012; by permission).



East Kauai Region

Kauai's eastern coast is characterized by embayments and fringing reef systems. The shore is exposed to northeast trade winds. Streams and rivers flow into the embayments, sometimes causing coastal flooding (Fierstein and Fletcher 2004). The Kapaa region of this coast was once a series of embayments, but has been straightened as a result of sediment infilling (Moberly and Chamberlain 1964, Fierstein and Fletcher 2004). East Kauai is the most erosional region of Kauai.[1]

The East Kauai region consists of the Nukolii, Waipouli, Kapaa, Lae Lipoa, Anahola, Kuaehu Point, and Aliomanu sub-regions (Figure 5). Kuaehu Point is experiencing the largest rate of shoreline recession within the region. The average shoreline recession in this sub-region is approximately -0.75 m/yr while the central portion of the sub-region is experiencing a recession rate of -1.5 m/yr. Other recession hot spots in the region include areas of Nukolii and the northern limit of Kapaa. (A recession hot spot is defined as an area of a beach with high erosion rate as compared to the adjacent shoreline (Kraus and Galgano 2001).) Shoreline advance has occurred in the short term in the Waipoli and Anahola sub-regions. Shoreline change within the remainder of the region generally varies from 0.5 to -0.5 m/yr.

South Kauai Region

Kauai's southern coast is exposed to Kona storm waves, trade wind waves, and southern swell. Longshore currents transport sediment westward from the mouths of large rivers (for example, Hanapepe Stream) (Fierstein and Fletcher 2004). Hurricane Iwa (1982) and Hurricane Iniki (1992) devastated this area, which was inundated as far as 300 m inland at Poipu (Fletcher et al. 2002).[1]

The Waimea sub-region lacks a shallow near-shore reef and has a wide, steep beach with a high proportion of terrigenous sediment (relative to typical calcareous Hawaiian beaches) from the Waimea River. The west end of the Hanapepe sub-region is composed of narrow, gently sloping, calcareous beach. The remainder of the Hanapepe and the Poipu subregions is composed of rejuvenated volcanic basalt with calcareous pocket beaches and fringing reef. The Mahaulepu sub-region contains lithified sand dunes

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[1] This paragraph was extracted verbatim from Fletcher et al. 2012, by permission.

(Makai Ocean Engineering and Sea Engineering 1991, Fierstein and Fletcher 2004).[1]

Sub-regions in the South Kauai region include Kikiaola Shallow Draft Harbor, Waimea, Koki Point, Salt Pond, Lawai, Poipu, Shipwreck, and Mahaulepu Bay (Figure 6). The result of the previously mentioned terrigenous sediment input to the littoral system from the Waimea River and the interruption of westerly sediment transport Kikiaola Harbor are apparent in the Waimea sub-region. Shoreline advance dominates along the entire sub-region with an average rate of 0.75 m/yr and maximum of 1.50 m/yr. East of the Waimea River, the shoreline is generally stable through Koki Point. At that point, the shoreline is receding at a rate of over -1.0 m/yr. Other recession hot spots are noted in the Salt Pond and Lawai sub-regions. The shoreline is slightly recessional through the remaining sub-regions of Poipu, Shipwreck, and Mahaulepu Bay.

West Kauai Region

Kauai's western coast is located on the Mana coastal plain, and is characterized by gently sloping beaches. The Mana Plain extends 5 km inland and is the product of converging longshore sediment transport from the north and southeast. Sediment transport from the north is driven by North Pacific swell and trade winds in winter; the transport from the southeast is driven by summer southern swell and trade winds (Moberly 1968). The shoreline is composed of calcareous sand with outcrops of beach rock. Most of the beaches in this area are wide and backed by an extensive sand dune system.[1]

The Polihale, Majors Bay, Oomano, and Kikiaola Shallow Draft Harbor sub-regions comprise the West Kauai region (Figure 7). Kikiaola Shallow Draft Harbor sub-region is included in the East Kauai as well as West Kauai regions since the Harbor impacts the westerly transport of sediment and, therefore, induces advance and recession on its updrift and downdrift shorelines, respectively. In the short term, shoreline advance dominates in the region. Significant areas of shoreline advance are documented at the northern limit of the Polihale sub-region (2.0 m/yr) and Majors Bay (2.0 m/yr). The shoreline recession signal decreases westward from Kikiaola Harbor starting at a rate of 0.75 m/yr near the harbor to nearly 0.00 m/yr at the boundary between the Oomano and Majors Bay sub-regions. Table 3 provides a summary of maximum shoreline change rates on the Island of Kauai.

[1] This paragraph was extracted verbatim from Fletcher et al. 2012, by permission.

Table 3. Maximum shoreline change rates on Kauai (Table 6 of Fletcher et al. 2012; by permission).

Region	Long-term rate (m/yr)	Location[1]	Short-term rate (m/yr)	Location[1]
		North		
Max. erosion	-0.7 ± 0.6	Haena Point	-1.0 ± 2.6	Kauapea, seasonal variability
Max. accretion	0.7 ± 0.7	Hanalei Bay, near middle	0.8 ± 1.5	Kahili Beach, near Kilauea Stream
		East		
Max. erosion	-0.7 ± 0.4	Aliomanu Beach, west end	-1.6 ± 0.3	Anahola, Kuaehu Point
Max. accretion	0.7 ± 0.4	Anahola Stream mouth	1.1 ± 0.6	Anahola Stream mouth
		South		
Max. erosion	-1.5 ± 0.4	Pocket Beach near Koki Point[2]	-1.7 ± 9.9	Lawai Bay, east end, beach lost[2]
Max. accretion	1.4 ± 0.7	Waimea, east side Kikiaola Harbor	1.7 ± 0.3	Waimea, east side Kikiaola Harbor
		West		
Max. erosion	-1.4 ± 0.2	Oomano, west side Kikiaola Harbor	-1.5 ± 0.3	Oomano, west side Kikiaola Harbor
Max. accretion	1.6 ± 1.8	Majors Bay, seasonal variability[2]	2.8 ± 6.2	Polihale, seasonal variability[3]

[1]Locations shown in Figures 4 through 7.

[2]Maximum erosion or accretion for Kauai.

[3]Maximum erosion or accretion for three Islands (Kauai, Oahu, and Maui).

Island of Kauai PDT Meeting

The Kauai Project Delivery Team (PDT) met on 21 September 2012 to discuss needs and opportunities to implement RSM activities. Key topics by USGS-defined regions discussed at the meeting include the following.

North Kauai Region

Hanalei River

Sediment has in-filled the river bed. There is not enough capacity in the river bed to convey flood waters. Hanalei Town experiences flooding during significant rainfall events. Non-structural flood control may be warranted (hau tree and mangrove removal).

Black Pot Beach

Kauai County has two boat ramps at the mouth of the river. The ramps and the river mouth have the potential to clog with sediment.

East Kauai Region

Kapaa Beach

Kauai County has prepared a detailed study of the coastal processes in this region (Sea Engineering, Inc. prepared the report). Study findings indicate

that the federally authorized Kapaa Shore Protection Project groin (north of the Moikeha Canal) may be redirecting sand to the offshore. There is a need to investigate the project features and determine if re-nourishment is authorized.

Waikaea Canal boat ramp

The boat ramp was recently dredged, and Kauai County has stockpiled approximately 3,000 cy of beach quality sand for future re-nourishment of the adjacent shoreline.

Aliomanu Beach

Houses and road are currently threatened by shoreline erosion.

Wailua River

The State of Hawaii maintains sediment that accumulates at the river mouth. Erosion that occurred in the summer of 2012 at Wailua Beach was most likely caused by strong east trade-wind waves that pushed sand toward the river mouth as well as offshore. The river continually changes course but has not been flowing strongly in recent years. With consistent rainfall, sand that has accumulated at the mouth of the river would potentially be flushed oceanward. It is unclear what mechanism would bring the sand back to the shoreline. There does not appear to be adequate volumes at the river mouth to replenish the entire length of eroding shoreline. Historically there have been seasonal erosion problems at the river mouth. The river has also changed course in the past and flowed to the north (parallel to the highway). An adjacent parking lot was threatened by erosion at that time (although that is currently not the situation).

Kealia Beach

Seasonal shifting of sand causes temporary shoreline erosion problems. There may be a way to implement the USACE Engineering With Nature (EWN) program strategies within the region. EWN is a new program that develops solutions to riverine and coastal engineering problems by taking advantage of natural systems and processes.

South Kauai Region

Poipu Beach

Episodic shoreline retreat has been experienced. In mid-to-late January 2013 the tombolo was washed out by a significant east swell. Erosion was experienced on the beach.

Kauai County is planning a small-scale beach nourishment project for Poipu Beach Park using washed sand from the Mana Plain. There are long-term plans for a larger beach nourishment project utilizing sand from offshore, but funding is presently not available. Other areas in the region that would benefit greatly from beach nourishment are the beach in front of the Sheraton Hotel as well as Waiohai Beach.

Breneke Beach

Sand from the Mana Plain in west Kauai was used to nourish the beach. Much of the material has cemented. There is a need to investigate sand washing techniques and their effectiveness.

Kukuiula Harbor

As part of the mitigation plan for the construction of the nearby golf course, the shoreline on the inside of the Harbor has been reclaimed from private ownership. The beach is scheduled to be nourished, at which time it will be turned over to Kauai County for management. RSM efforts should focus on identifying suitable sand sources. Mana Plain is one possible source.

Port Allen Harbor

The shoreline inside the Harbor is receding. A revetment was constructed to stabilize the shoreline, and there is presently no dry beach fronting the structure. Dredged material could be placed in the area or on the adjacent sandy shoreline.

West Kauai Region

Kikiaola Shallow Draft Harbor

This Harbor is the primary RSM challenge for POH at the present time. Sediment is intercepted by the east breakwater, entrance channel, access

channel, and harbor basin. The down-drift shoreline is eroding. Sediment needs to be bypassed, the Harbor needs to be dredged, and a long-term RSM strategy needs to be developed.

Kekaha Beach

Currently, the State of Hawaii is constructing a pile dike north of the federally authorized revetment in an attempt to save the State highway from undermining. RSM and EWN methods should be developed to maintain sufficient beach width fronting the highway.

Hanapepe River

Sediment is building up within the river alignment and increasing flood vulnerability. Removal of the sediment and its ultimate beneficial use could be facilitated by RSM and EWN.

Waimea River

Sediment is building up within the river alignment and increasing flood vulnerability. Removal of the sediment and its ultimate beneficial use could be facilitated by RSM and EWN. In general, stream-clearing guidance needs to be developed for Kauai County to ensure that the sediment is beneficially used and that there are no adverse environmental impacts associated with its use.

Island of Kauai PDT RSM General Comments

The State of Hawaii, Department of Health, Clean Water Branch (CWB), issues water quality certifications for beach-fill projects. Historically, acquiring water quality certification from CWB has been a challenging process. Programmatic coordination with CWB regarding the goals of RSM, and regarding the importance of utilizing the State's valuable sediment resources, should be conducted to streamline the water quality certification process for RSM actions.

Stockpiling beach quality sand for future use as beach fill would be a worthwhile initiative.

3 Island of Oahu

"Oahu is the third largest and most populated island of all the Hawaiian Islands" (Fletcher et al. 2012; by permission). There are two federally authorized deep-draft harbors, Honolulu Harbor and Barbers Point Harbor, on the Island of Oahu. The non-federal sponsor of the deep-draft harbor projects is the State of Hawaii, Department of Transportation. Honolulu Harbor handles over 11 million tons of cargo annually and is a critical resource since Hawaii imports over 80% of its required goods. Not only does Honolulu Harbor serve the Island of Oahu's waterborne commerce needs, but a vast percentage of the goods and commodities that enter the harbor are ultimately barged to the outer islands. Barbers Point Harbor is a relatively new facility constructed in 1985 out of fast land (land located above the high water line) at the southwest corner of the island. The facility specializes in receipt and shipment of conventional and containerized general cargo and petroleum products, receipt of miscellaneous dry bulk commodities and grain, shipment of cement, and bunkering of vessels. There are two federally authorized small boat harbors, Haleiwa Harbor and Waianae Harbor, on the Island of Oahu. Both of these harbors provide opportunities for commercial and recreational boating. The non-federal sponsor of the small boat harbor projects is the State of Hawaii, Department of Land and Natural Resources, Division of Boating and Ocean Recreation (DOBOR).

Figure 8 provides approximate locations of the federally authorized navigation and shore protection projects on the Island of Oahu. The figure also indicates areas where sediment might be available, portions of shoreline that are experiencing erosion in the short term, and places that could potentially be off limits to RSM activities for various reasons.

The federally authorized projects of interest on the Island of Oahu include (a) Honolulu Deep Draft Harbor, (b) Barbers Point Deep Draft Harbor, (c) Waianae Small Boat Harbor, (d) Haleiwa Small Boat Harbor, (e) Haleiwa Shore Protection Project, (f) Kaaawa Shore Protection Project, (g) Waikiki Beach Shore Protection Project, and (h) Sand Island Shore Protection Project.

Figure 8. Locations of federally authorized navigation projects (stars) and shore protection projects (yellow triangles) on Island of Oahu that could benefit from RSM activities.

Dredging History

Honolulu Harbor has been dredged seven times since 1968 (Table 4). The most recent dredging event at the Harbor was in 1999 at which time 154,000 cy of material were removed at a cost of $1,316,800 (resulting in a unit cost of $8.55/cy). The greatest and least volumes of material dredged from Honolulu Harbor were 1,000,000 cy and 122,693 cy in 1981 and 1968, respectively. The 1968 dredging event resulted in the lowest unit cost on record for that project ($0.54/cy). Maintenance dredging of 91,000 cy at a cost of $1,212,480 took place at Barbers Point Harbor in 1999 (with a unit cost of $13.32/cy). Only minor amounts of dredging have been required to maintain authorized depths at the Haleiwa and Waianae Small Boat Harbors. Haleiwa Harbor was dredged in 1999 and again in 2009 with volume removed of 4,500 cy and 6,500 cy, respectively. Waianae Small Boat Harbor was also dredged in 2009, at which time approximately 2,000 cy of sediment were removed from the federal channel. The unit cost for these dredging events ranged from $153.85/cy to $247.00/cy. The high unit costs of these maintenance dredging projects was due to the high cost of contractor mobilization and demobilization relative to the small volume of sediment required to be dredged.

Table 4. Summary of federally authorized navigation project dredging on Island of Oahu.

YEAR	ISLAND	PROJECT	VOLUME [cy]	COST [$]	UNIT COST [$/cy]
1999	OAHU	BARBERS PT HBR	91,000	$1,212,480	$13.32
2009	OAHU	HALEIWA SBH	6,500	$1,000,000	$153.85
1999	OAHU	HALEIWA SBH	4,500	$1,000,000	$222.22
1999	OAHU	HONOLULU HBR	154,000	$1,316,800	$8.55
1990	OAHU	HONOLULU HBR	135,000	$498,520	$3.69
1983	OAHU	HONOLULU HBR	212,000		
1981	OAHU	HONOLULU HBR	1,000,000		
1977	OAHU	HONOLULU HBR	456,923	$445,672	$0.98
1972	OAHU	HONOLULU HBR	188,000		
1968	OAHU	HONOLULU HBR	122,693	$66,004	$0.54
2009	OAHU	WAIANAE SBH	2,000	$494,000	$247.00

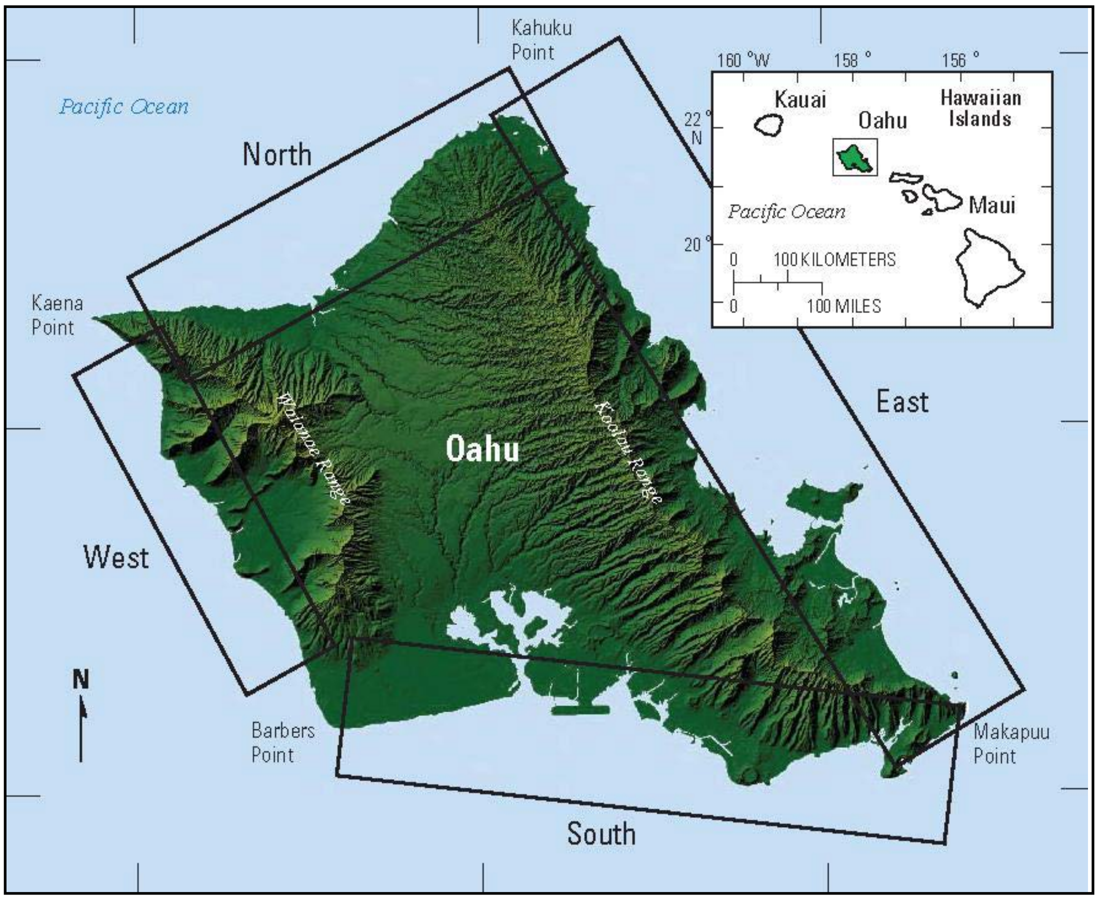
Shore Protection

Federally authorized shore protects have been constructed at Haleiwa Park, Kaaawa, and Sand Island. The federally authorized shore protection project for Waikiki Beach has yet to be constructed. Haleiwa and Kaaawa Shore Protection Projects could potentially be beneficiaries of future RSM activities. However, the Sand Island Shore Protection Project consists of a rubble-mound revetment and three segment breakwaters without a beach-fill component.

Shoreline Change

The Island of Oahu has approximately 107 km of sandy beach that has been separated into four regions by USGS (North, East, South, and West) to facilitate investigation of historical shoreline change (Figure 9).

Figure 9. Four regions of Oahu (north, east, south, and west) (Figure 22 of Fletcher et al. 2012; by permission).

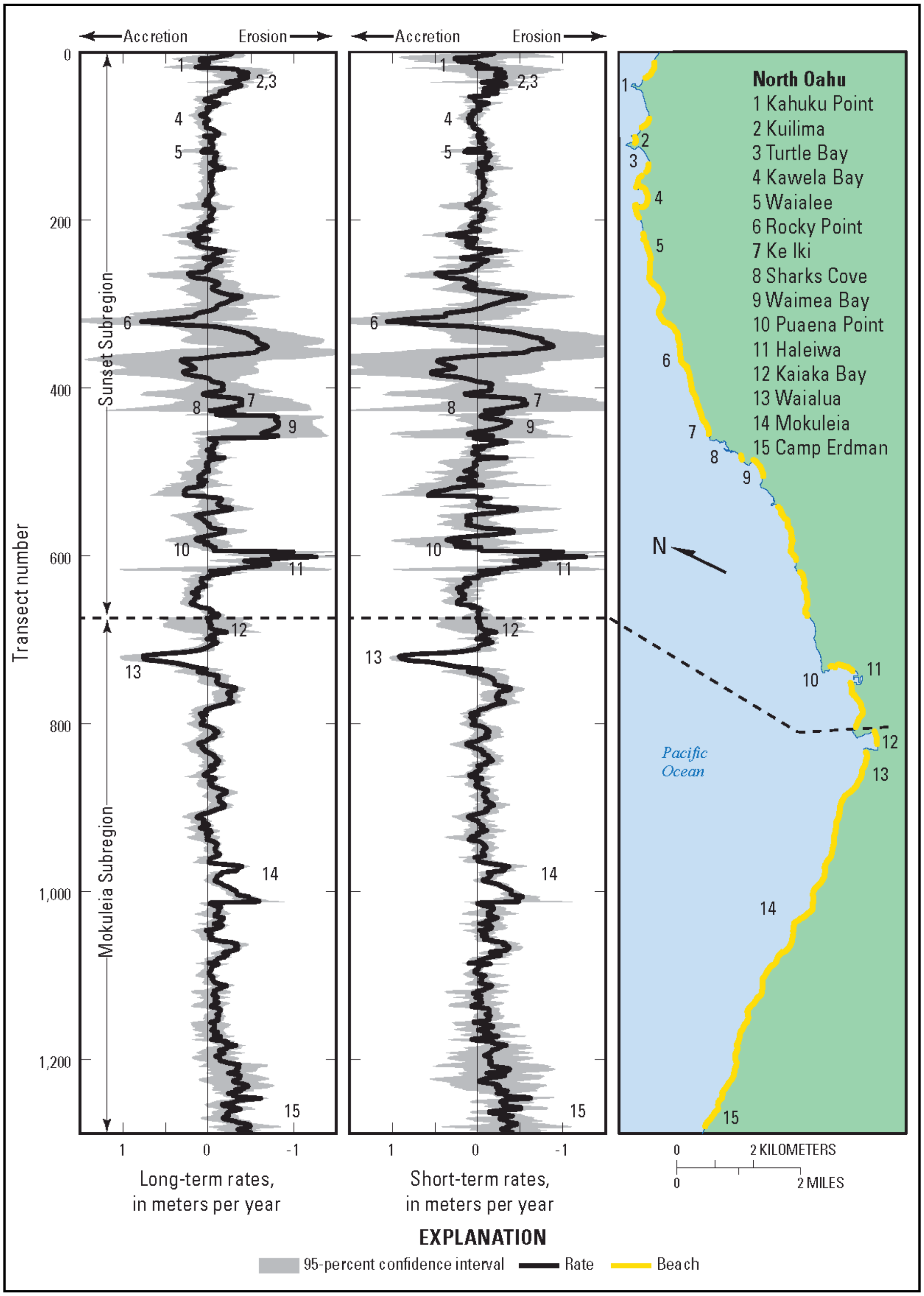


North Oahu Region

The maximum long-term erosion rate (-1.3 ± 0.8 m/yr) was found at Haleiwa Beach Park at a segment of shoreline behind a small breakwater where the beach has been lost [Figure 10]. This beach has undergone substantial modification throughout its history, including construction of a groin, breakwater, seawall, and two beach nourishment projects (Hwang 1981; Sea Engineering, Inc. 1988).[1]

[1] This paragraph was extracted verbatim from Fletcher et al. 2012, by permission.

Figure 10. Long-term (all available years) and short-term (1940s to present) shoreline change rates, North Oahu (location shown in Figure 9) (Figure 24 of Fletcher et al. 2012; by permission).



The federally authorized Haleiwa Shore Protection Project includes a 520 ft-long groin, a 160 ft-long offshore breakwater, and beach fill backed by a vertical seawall (Figure 11). Currently, erosion is threatening bathing and restroom facilities located behind the offshore breakwater. Regional sediment management techniques could be used to alleviate the erosion problems currently being experienced at Haleiwa Beach Park.

Figure 11. Google image (30 July 2006)–Haleiwa Small Boat Harbor and the Haleiwa Shore Protection Project.

The maximum long-term accretion rate (0.8 ± 0.8 m/yr) was measured at Rocky Point in the Sunset sub-region, though this rate is likely affected by seasonal variability and/or biased toward two summer shorelines at the end of the analysis period.[1]

East Oahu Region[2]

Oahu's eastern coast faces into the predominant easterly trade winds. As a result, the shoreline is exposed to short-period trade wind waves year round. Shallow fringing reef that lines much of East Oahu protects the shoreline from the full energy of large waves. However, beaches that back shallow protective reefs are typically low and narrow and are prone to inundation during large waves and storms. More transects are erosional in the short term than in the long-term rates, with erosion occurring at 54% of transects and accretion occurring at 44%.

East Oahu is divided into two sub-regions, Northeast and Southeast, separated by Kaneohe Bay [Figure 12]. The back-bay shoreline of Kaneohe Bay was not included in this study. The beach at central Lanikai is accreting at up to 0.8 ± 0.3 m/yr; however, the beach along the adjacent shoreline to the north and south has been lost to erosion (seawalls) in the last few decades.

South Oahu Region[2]

Waikiki Beach was originally a wetland with a narrow strip of sandy beach. Development in this region started in the late 1800s, and the construction of a canal was proposed to divert streams from Waikiki, facilitating additional development. As development increased in the early 20th century, beach erosion became an increasing problem. Seawalls and groins were constructed and beach nourishment projects were pursued to maintain a healthy beach. Nourishment of Waikiki Beach has continued into the 21st century, with the most recent nourishment project occurring in early 2012 (24,000 square yard (sq yd)).

The maximum long-term erosion rate (-1.6 ± 2.7 m/yr) was found at Queens Beach, Waikiki, where the shoreline is hardened and much of the beach disappeared prior to 1975 [Figure 13]. Erosion up to -1.6 ± 0.4 m/yr is also

[1] This paragraph was extracted verbatim from Fletcher et al. 2012, by permission.

[2] These sections (East Oahu Region / South Oahu Region) were extracted essentially verbatim from Fletcher et al. 2012, by permission.

Figure 12. Long-term (all available years) and short-term (1940s to present) shoreline change rates, East Oahu (location shown in Figure 9) (Figure 26 of Fletcher et al. 2012; by permission).

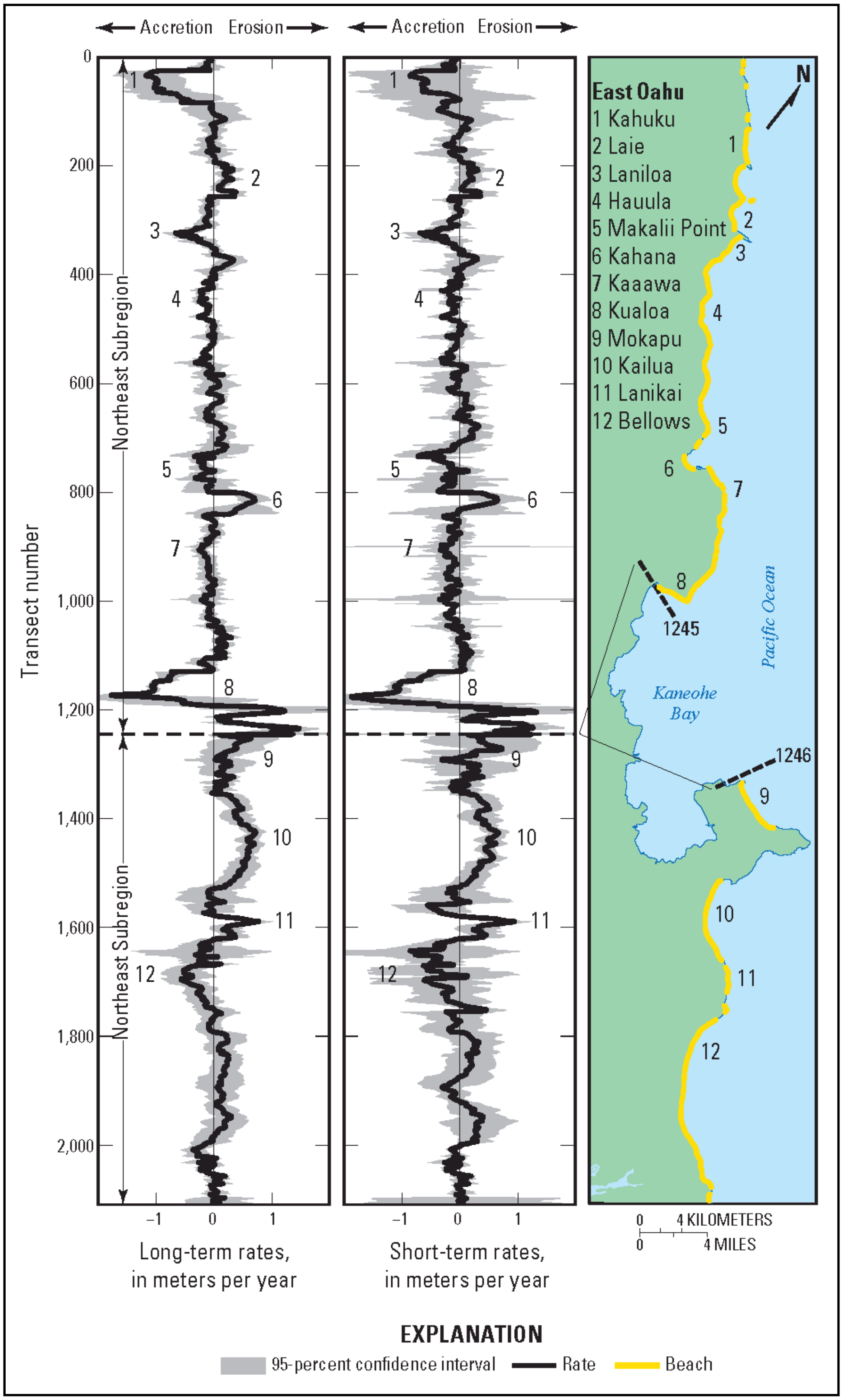
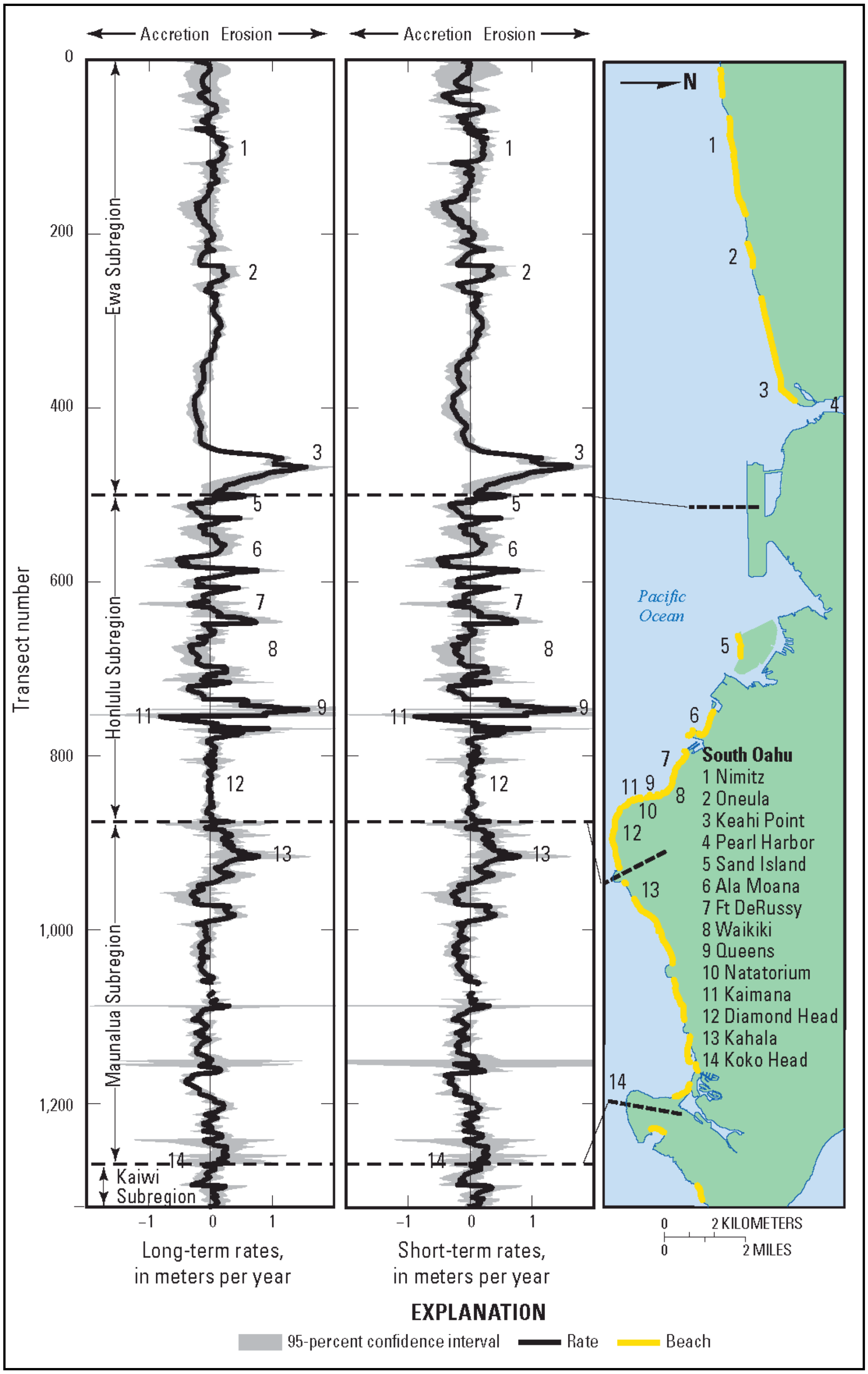


Figure 13. Long-term (all available years) and short-term (1940s to present) shoreline change rates, South Oahu (location shown in Figure 9) (Figure 29 of Fletcher et al. 2012; by permission).



occurring at the eastern end of the Ewa sub-region near the Pearl Harbor entrance channel (Keahi Point), where erosion of a sandy headland has forced the removal of several homes and prompted construction of a boulder revetment. The maximum long-term accretion rate (0.8 ± 0.2 m/yr) was found at Kaimana Beach in Waikiki, on the eastern side of the natatorium. The natatorium walls act as a groin, disrupting the westerly longshore transport of sediment and resulting in accretion on the eastern side of the natatorium (Kaimana) and erosion on the western side (Queens). The maximum short-term erosion and accretion rates were measured at the same locations as the maximum long-term erosion and accretion rates, respectively (Kaimana and Queens, Waikiki).

West Oahu Region

Shoreline position is highly variable at many beaches in this region, as sand shifts alongshore with alternating wave direction between the North Pacific and southern swell seasons. West Oahu is the most erosional region of the Island, with an average long-term rate of -0.25 ± 0.01 m/yr and 83% of transects indicating erosion in the long term. The maximum long-term erosion rate (-1.2 ± 0.5 m/yr) was found in the northern part of Maili Beach [Table 5] and is at least partly the result of removal of sand by mining operations in the mid-1900s (Hwang 1981; Sea Engineering, Inc. 1988). Sand mining was widespread along western Oahu beaches and also likely affects shoreline change rates at Makua and Yokohama (Campbell and Moberly 1978, Hwang 1981).[1]

The maximum accretion rate (1.7 ± 0.6 m/yr) was found in the southern part of Pokai Bay [Figure 14]. This section of beach has been accreting since the construction of a breakwater in the 1950s. The short-term rates at Yokohama, Keaau, and Maili are less erosive than the long-term rates, indicating that shoreline recession may have slowed since sand-mining operations ceased.[1]

Table 5 provides a summary of maximum erosion and accretion by region for the island of Oahu. Long-term and short-term rates are displayed in the table, along with the uncertainty of each value in meters per year.

[1] This paragraph was extracted essentially verbatim from Fletcher et al. 2012, by permission.

Figure 14. Long-term (all available years) and short-term (1940s to present) shoreline change rates, West Oahu (location shown in Figure 9) (Figure 30 of Fletcher et al. 2012; by permission).

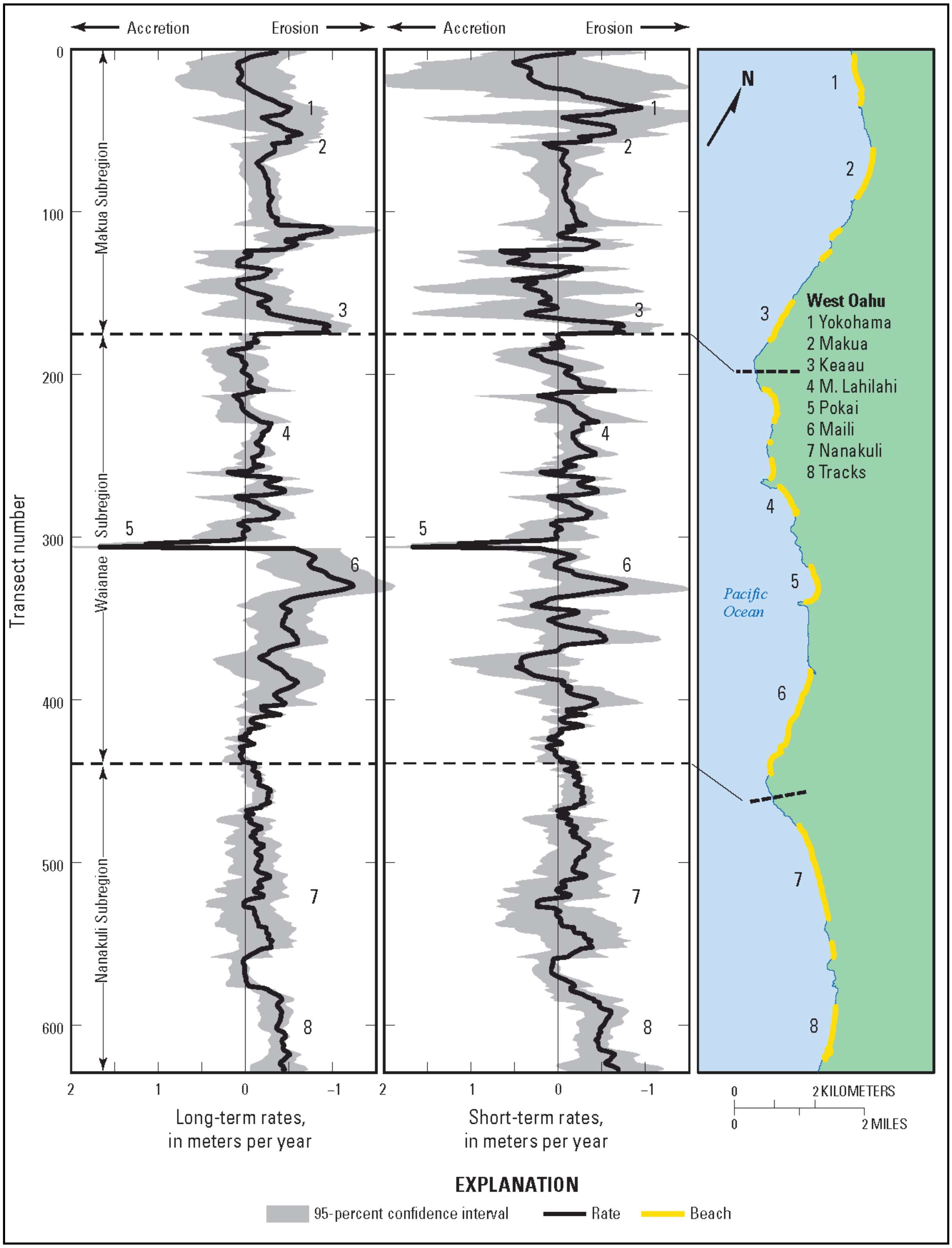


Table 5. Maximum shoreline change rates on Oahu (Table 9 of Fletcher et al. 2012; by permission).

Region	Long-term rate (m/yr)	Location[1]	Short-term rate (m/yr)	Location[1]
		North		
Max. erosion	-1.3 ± 0.8	Haleiwa Beach Park, beach lost	-1.3 ± 0.8	Haleiwa Beach Park, beach lost
Max. accretion	0.8 ± 0.8	Rocky Point, high seasonal change	1.1 ± 0.9	Rocky Point, high seasonal change
		East		
Max. erosion	-1.8 ± 0.3	Kualoa Point[2]	-1.9 ± 0.9	Kualoa Point[3]
Max. accretion	1.5 ± 0.4	Kaneohe Bay, west of Kualoa Point	1.3 ± 1.8	Kaneohe Bay, west of Kualoa Point
		South		
Max. erosion	-1.6 ± 2.7	West side Natatorium, beach lost	-1.6 ± 2.7	West side Natatorium, beach lost
Max. accretion	0.8 ± 0.2	Kaimana, south side Natatorium	0.9 ± 0.3	Kaimana, east side Natatorium
		West		
Max. erosion	-1.2 ± 0.5	Maili, sand mining	-1.0 ± 0.3	Yokohama, sand mining
Max. accretion	1.7 ± 0.6	Pokai Bay, north of harbor breakwall[2]	1.7 ± 0.6	Pokai Bay, north of harbor breakwall[3]

[1]Locations shown in Figures 10, 12, 13, and 14.

[2]Maximum erosion or accretion for Oahu.

[3]Maximum erosion or accretion for three islands (Kauai, Oahu, and Maui).

Island of Oahu PDT Meeting

The Island of Oahu PDT met on 1 November 2012 to discuss needs and opportunities to implement RSM activities. Key topics by USGS-defined regions discussed at the meeting include the following.

North Oahu Region

Haleiwa Sub-region

The FY13 RSM scope of work for POD incorporates investigation of Federal navigation and shore protection projects in the Haleiwa Region. The region extends from west of Haleiwa Small Boat Harbor to the east of Haleiwa Beach Park (Figure 11). Federal general navigation features at the Harbor include entrance and access channels as well as a revetted mole and breakwater. Analysis of the impacts of the Harbor on adjacent shorelines and potential sand bypassing operations to restore the beach fronting the park are yet to be conducted. Sand that accumulates on Alii Beach adjacent to the state-owned breakwater will be considered for bypassing. Currently, backpassing of sand along the park shoreline is not being conducted by the City and County of Honolulu (C&C) due to lack of permits to place the sediment in the water. The State of Hawaii Department of Health (DOH) and POH need to be consulted to secure permits to move sand from the accretional fillet to the eroding eastern shoreline.

Waialua Beach

Erosion threatens shoreline development along Waialua Beach Road.

Laniakea Beach

Investigate the impacts of the dumped rock along the shoreline between the Laniakea Beach lifeguard station and Honulani Beach.

Sharks Cove to Velzyland

Consider the seasonal fluctuations in beach width along this stretch of shoreline.

East Oahu Region

Punaluu and Hauula

Shoreline recession threatens the highway in these areas. The State of Hawaii Department of Transportation (DOT) has dumped rocks in certain locations in an attempt to stabilize the shoreline. Permanent solutions to the shoreline recession problems are being developed by DOT. Sediment management may be able to address a portion of the problem.

Kaaawa

There is an authorized Federal shore protection project at Kaaawa. Initial construction of the project was cost shared with the C&C. The C&C is responsible for operation and maintenance of the project. The shoreline has receded to pre-project conditions and should be considered for nourishment. Sand that accumulates at stream mouths adjacent to the project might be able to be backpassed to the project area.

Kaelepulu Stream

Hawaii RSM has investigated sand backpassing from the stream mouth. The C&C recently relocated approximately 6,000 cy of sand from the stream banks to above the mean high waterline along the shoreline extending to the boat ramp in April 2012. Coordination with DOH and POH Regulatory Division should be initiated to determine the necessary permit actions required to allow for the sand to be placed back into the littoral system.

Lanikai

Conditions documented by Hawaii RSM have not improved over the past few years. An update of shoreline locations along Lanikai Beach would facilitate quantification of the need to implement the Lanikai Beach Restoration Pilot Project.

Bellow Air Force Station (AFS)

Removing the revetment at Bellow AFS or constructing a beach-fill project seaward of the structure remains a top RSM priority on the Island of Oahu.

South Oahu Region

Kahala

Beach rock has been exposed along much of the beach in this region indicating active shoreline recession. The condition renders the beach face narrow and hazardous to beachgoers. Investigation of various options for restoring the beach should be developed.

Fort DeRussy

A multi-agency team is assisting Hale Koa Hotel staff in the development of a backpass plan for Fort DeRussy Beach. Sand that has accumulated at the west limit of the beach would be hauled to the eroding eastern shoreline.

Ala Moana Beach

The central portion of Ala Moana Beach has eroded to the seawall. There is a need to redistribute the remaining sand in the area or bring in new material. Many areas of the beach have become rocky and unsuitable for typical beach activities.

Iroquois Point

A private development company has negotiated partial ownership of the Iroquois Point housing development. It is constructing nine T-head groins and is planning to place approximately 80,000 cy of beach-quality sand along the development shoreline. A portion of the sand has been stockpiled from previous dredging operation for Pearl Harbor

(approximately 20,000 cy). The balance of the material is also to come from Pearl Harbor channel dredging.

West Oahu Region

Mauna Lahilahi Beach Park

The C&C built a breakwater offshore of the beach park. The structure was placed too close to the shoreline, and the beach has responded negatively. Adjustment of the shoreline in response to the breakwater has exposed the revetment fronting the condominium. RSM principles could be utilized to reduce shoreline recession of the park property.

Pokai Bay

Erosion issues should be investigated in Pokai Bay. Impacts of navigation features on the Bay shoreline should be quantified.

Makaha Beach

Cyclical shoreline recession impacts Makaha Beach. Residents in the area moved sediment from the stream mouth to the northern limit of the beach in February 2011. The beach should be monitored to ensure that the stream mouth sediment is backpassed prior to the onset of critical recession.

Island of Oahu PDT RSM General Comments

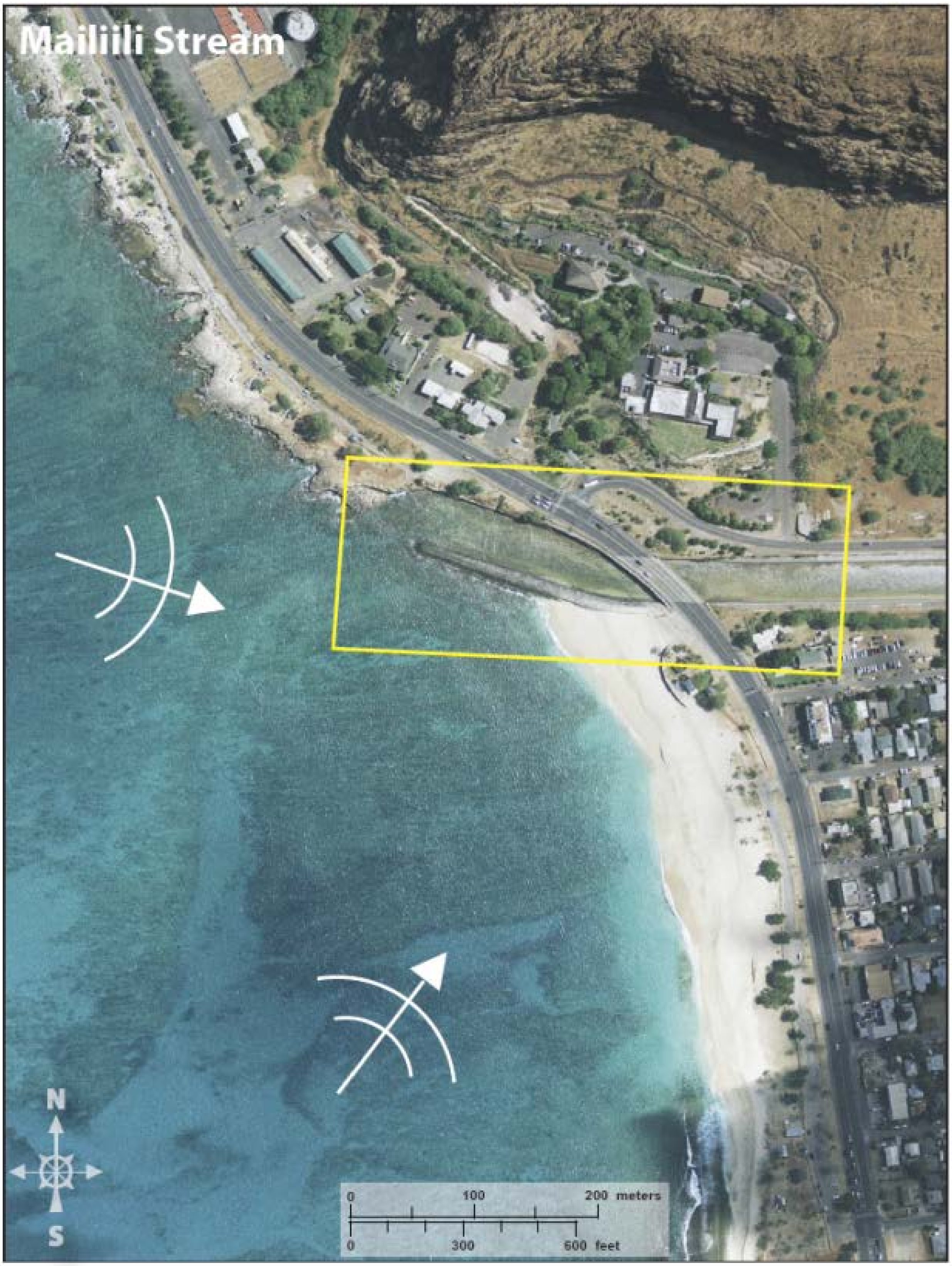
The City and County of Oahu's regional sediment management priorities include Haleiwa and Ala Moana beach parks.

Sediment management at stream mouths is a major RSM issue on the Island of Oahu. Figure 15 is an aerial image of Ulehawa Stream showing sediment clogging the stream mouth. Conversely, Figure 16 is an aerial image of Mailiili Stream illustrating the effective use of a rubble-mound groin to keep sediment from clogging a stream mouth.

Water quality certification is one of the major road blocks to effectively managing littoral sediments on the Island of Oahu. Routine maintenance of infrastructure at and near the shoreline is hampered by the lack of urgency provided by the DOH Clean Water Branch.

Figure 15. Aerial image of Ulehawa Stream showing sediment clogging the stream mouth.

Figure 16. Aerial image of Mailiili Stream illustrating the effective use of a rubble-mound groin to keep sediment from clogging a stream mouth.



4 Maui County

Maui County consists of the Islands of Maui, Kahoolawe, Lanai, and Molokai. Lanai is a privately owned island, other than the state owned airport and the federally authorized navigation projects of Kaumalapau Harbor and Manele Small Boat Harbor. Kahoolawe is held in trust for a future Native Hawaiian sovereign entity and is managed by the Kahoolawe Island Reserve Commission. Since there are no federally authorized projects on Kahoolawe, the entire island is shown as being off limits to RSM activities. Figure 17 displays federally authorized projects in Maui County that could potentially benefit from implementation of RSM principles and practices. Areas that could potentially be used as sediment sources, areas of chronic erosion, and portions of the shoreline that may be off limits to RSM activities are also indicated.

Figure 17. Locations of federally authorized navigation projects (stars) and shore protection projects (yellow triangles) within Maui County that could potentially benefit from RSM activities.

The federally authorized studies and projects of interest in Maui County include (a) West Maui Watershed Study, (b) Kahului Deep Draft Harbor, (c)

Kahului Light Draft Harbor, (d) Kihei Shore Protection Project, (e) Manele Small Boat Harbor, (f) Kaumalapau Harbor, and (g) Kaunakakai Harbor.

Dredging History

Kahului Deep Draft Harbor has been dredged three times since 1977 (Table 6). Volumes dredged from the harbor have increased over the years: 24,000 cy (1977), 74,000 cy (1990), and 91,000 cy (1999) with corresponding increases in unit cost of $1.72/cy (1977), $5.78/cy (1990), and $9.07/cy (1999).

Table 6. Federally authorized navigation project dredging in Maui County.

YEAR	ISLAND	PROJECT	VOLUME [cy]	COST [$]	UNIT COST [$/cy]
2004	LANAI	MANELE SBH	9,000	$570,250	$63.36
1985	LANAI	MANELE SBH	2,000	$435,357	$217.68
1999	MAUI	KAHULUI DDH	91,000	$825,120	$9.07
1990	MAUI	KAHULUI DDH	73,700	$425,876	$5.78
1977	MAUI	KAHULUI DDH	24,329	$41,925	$1.72
1973	MOLOKAI	KAUNAKAKAI HBR	51,000	$240,649	$4.72

Approximately 51,000 cy of material were dredged from Kaunakakai Harbor (Molokai) in 1973. The unit cost of dredging was $4.72/cy. The 1985 unit cost for dredging at Manele Small Boat Harbor (Lanai) was one of the highest on record for POH at $217.68/cy. The high unit cost was due in part to the small amount of material dredged (2,000 cy) relative to the mobilization/demobilization cost. Subsequent maintenance of the harbor in 2004 consisted of the dredging of approximately 9,000 cy at a unit cost of $63.36/cy.

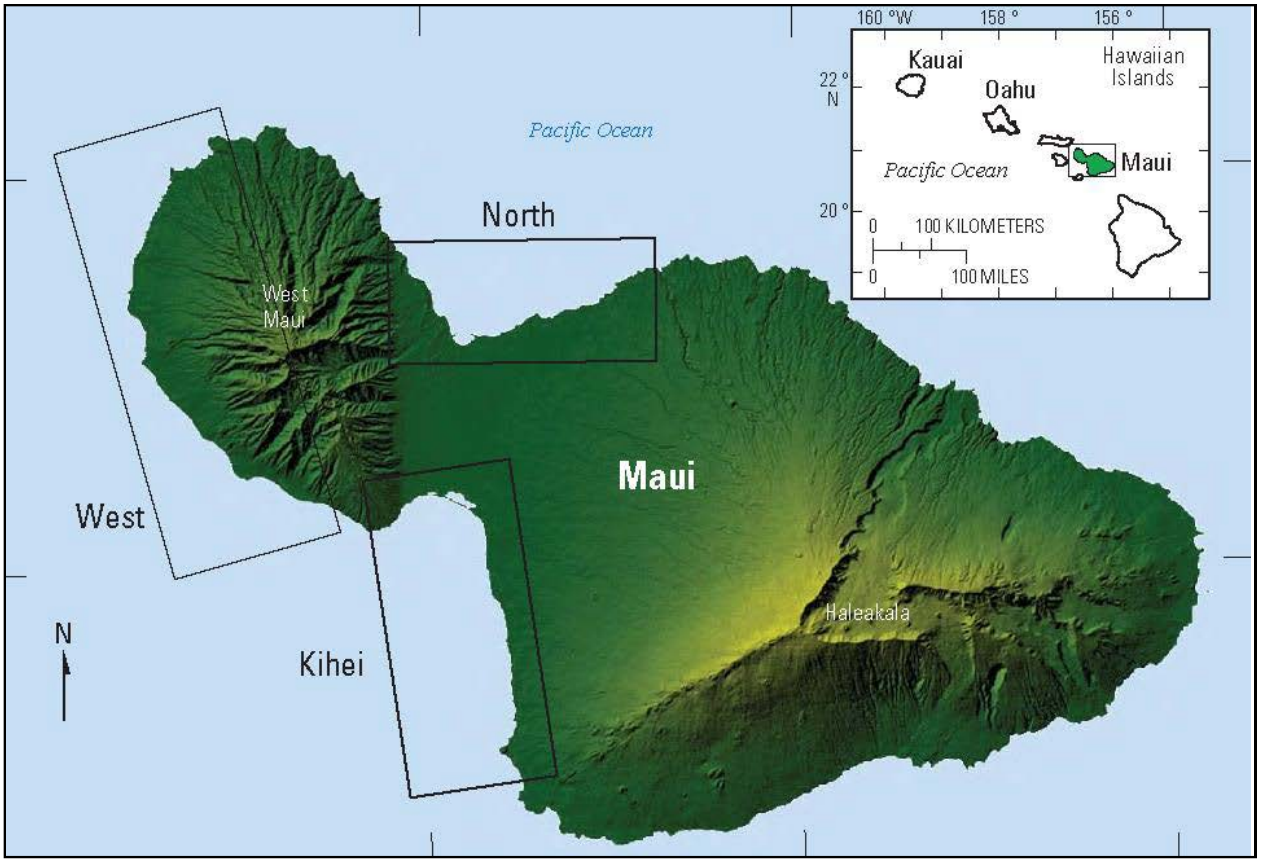
One RSM opportunity that should be investigated is at Manele Small Boat Harbor where a stream settling basin located upstream of the harbor is not effectively maintained. Once the settling basin has filled with stream sediments, additional sediments are allowed to discharge directly into the harbor basin. Routine maintenance of the settling basin would reduce harbor shoaling and navigation O&M costs. Records for Maui County do not indicate that any of the dredged material has been used beneficially.

Shoreline Change

The three coastal regions into which the USGS divided the Island of Maui to analyze shoreline change are shown in Figure 18. The Island of Maui is the

second largest of the Hawaiian Islands. It is composed of two shield volcanoes, West Maui and Haleakala, with a low-lying isthmus separating them. There are approximately 90 km of sandy beach on the Island of Maui.

Figure 18. Three regions of Maui (north, Kihei, and west) (Figure 32 of Fletcher et al. 2012; by permission).



Maui's beaches are the most erosional among the three Islands [(Kauai, Oahu, and Maui) investigated by the USGS (Fletcher et al. 2012)]. Average shoreline change rates for all analysis regions and subregions are erosional. The average long-term rate for all transects is -0.17 ± 0.01 m/yr and the average short-term rate is -0.15 ± 0.01 m/yr. A majority of the Maui transects indicate erosion with 85% of the long-term rates erosional and 76% of the short-term rates erosional. Eleven percent (6.8 km) of the total extent of Maui beaches studied was lost to erosion during the analysis period (the highest percentage of the three islands).[1]

[1] This paragraph was extracted verbatim from Fletcher et al. 2012, by permission.

North Maui Region[1]

The maximum erosion rate (-1.5 ± 1.1 m/yr) was found in front of an offshore rock bench at Baldwin Park [Figure 19]. Shoreline recession at Baldwin is, in part, the result of sand-mining operations for a now-defunct lime kiln. A bench of beach rock was previously linked to the beach by a tombolo, but is now isolated offshore (Genz et al. 2009). Other areas of significant erosion were found at Waiehu Beach Park (up to -0.5 ± 0.3 m/yr, long term) and Kanaha Beach Park (up to -1.5 ± 0.7 m/yr, long term). The maximum long-term accretion rate (1.5 ± 1.3 m/yr) was measured between two groins at Kanaha Beach Park.

The average short-term shoreline change rate for North Shore beaches, -0.22 ± 0.03 m/yr, is roughly the same as the average long-term rate. Seventy-four percent of the beach is erosional in the short term. The maximum short-term erosion rate (-2.2 ± 1.1 m/yr) was found in the same location as the maximum long-term erosion rate (Baldwin Park). The maximum short-term accretion rate (2.1 ± 0.2 m/yr), like the maximum long-term accretion rate, was found in Kanaha Beach Park. Short-term and long-term rates follow a similar pattern, though uncertainty is higher in the short-term rate because of the truncated data set.

Kihei Maui Region[1]

The maximum long-term erosion rate (-1.1 ± 0.6 m/yr) was found at Kawililipoa, in the remains of a fish pond [Figure 20]. Other areas with substantial long-term erosion include South Wailea (up to -0.5 ± 0.2 m/yr), North Wailea (up to -0.4 ± 0.2 m/yr), Kalama Park (up to -0.8 ± 0.5 m/yr; beach lost), and Maalaea (up to -0.6 ± 0.2 m/yr). The maximum long-term accretion rate (1.6 ± 0.4 m/yr) was also found at Kawililipoa, along an accretional cusp.

The average short-term rate is -0.12 ± 0.02 m/yr, and 77% of the short-term rates are erosional. The maximum short-term erosion rate (-1.8 ± 7.5 m/yr) was found at Kalepolepo Beach Park, where the beach has been completely lost to erosion. The maximum short-term accretion rate was found at the same location as the maximum long-term accretion rate (Kawililipoa, 1.8 ± 0.8 m/yr). Long- and short-term rates have similar overall trends.

[1] These sections (North Maui Region / Kihei Maui Region) were extracted verbatim from Fletcher et al. 2012, by permission.

Figure 19. Long-term (all available years) and short-term (1940s to present) shoreline change rates, North Maui (location shown in Figure 18) (Figure 33 of Fletcher et al. 2012; by permission).

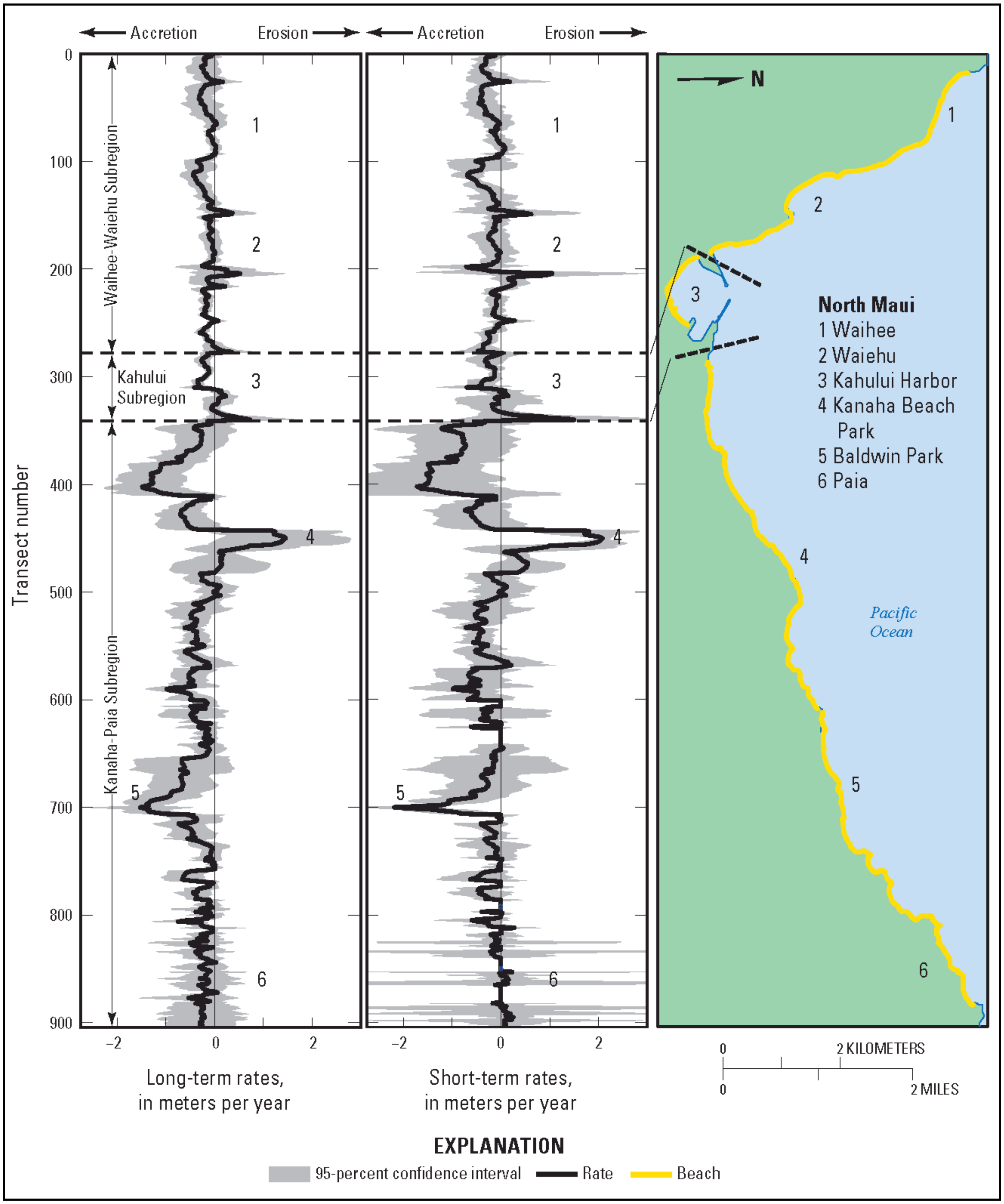
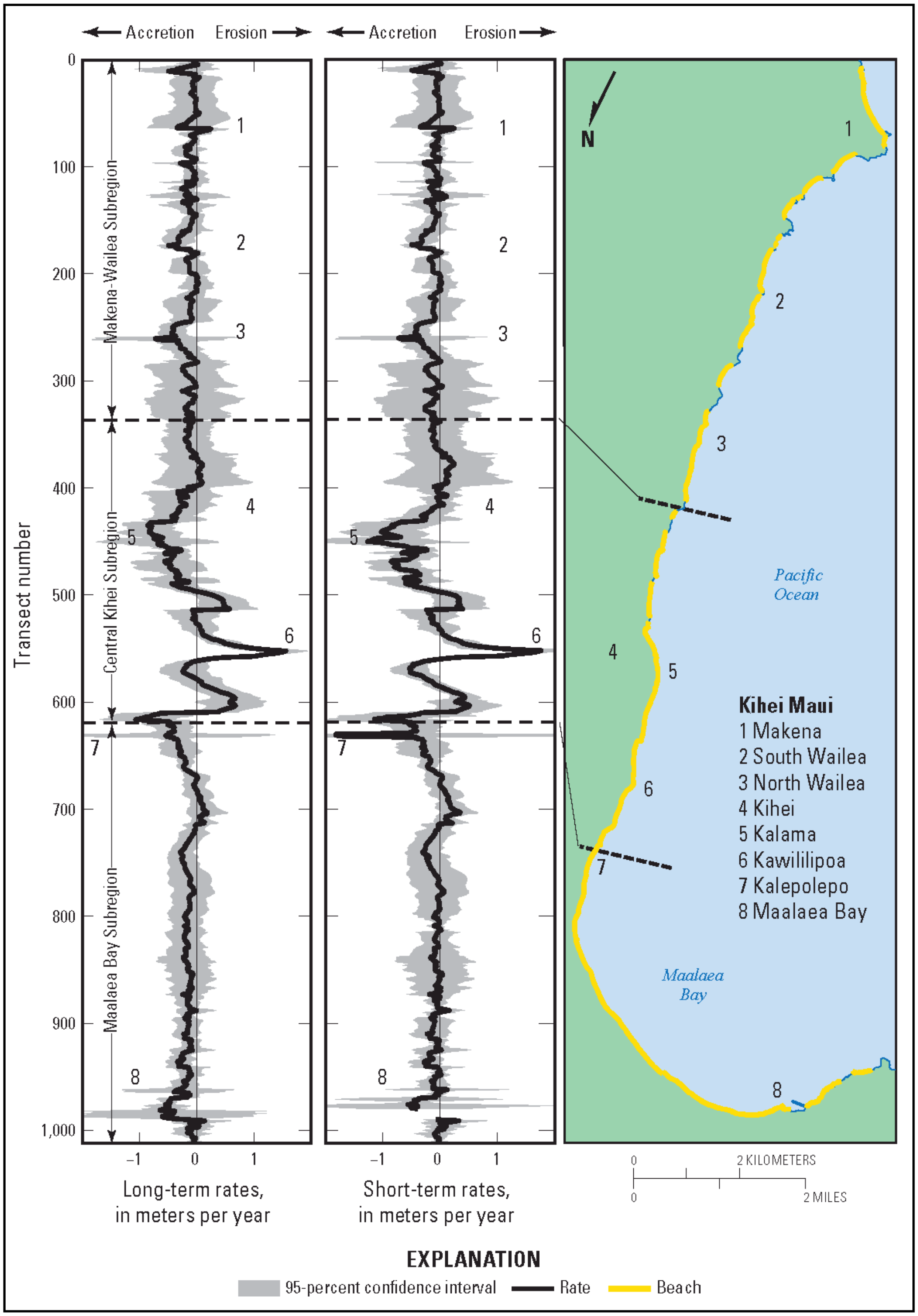


Figure 20. Long-term (all available years) and short-term (1940s to present) shoreline change rates, Kihei Maui (location shown in Figure 18) (Figure 35 of Fletcher et al. 2012; by permission).



West Maui Region[1]

The average of all long-term rates for West Maui is -0.15 ± 0.01 m/yr and 85 percent of transects are erosional in the long term [Figure 21]. All subregions in West Maui are erosional in the long and short term based on average rates. The Napili-Kapalua subregion has the highest average erosion rates, -0.22 ± 0.02 m/yr in the long term and -0.19 ± 0.03 m/yr in the short term. The maximum erosion rate (-0.9 ± 0.6 m/yr) was found at Ukumehame adjacent to a boulder revetment installed to protect the coastal highway. Other areas of significant long-term erosion include Hekili Point (up to -0.3 ± 0.2 m/yr), Olowalu (up to -0.3 ± 0.2 m/yr), Launiupoko (up to -0.5 ± 0.3 m/yr), Puamana (up to -0.5 ± 0.2 m/yr), Mala Wharf (up to -0.5 ± 0.4 m/yr), Honokowai (up to -0.5 ± 0.4 m/yr), Kahana (up to -0.4 ± 0.1 m/yr), and Napili Bay (up to -0.4 ± 0.2 m/yr).

Erosion at West Maui is slightly lower in the short-term than in the long-term rate, with an average short-term rate of -0.13 ± 0.01 m/yr, and 77% of transects are erosional. The maximum short-term erosion rate (-0.7 ± 1.7 m/yr) was found at Mokuleia Beach. The percentage of accretion increased from 14% (for long-term rates) to 18% (for short-term rates). The maximum short-term accretion rate was found at the same location as the maximum rate in the long-term analysis (Puunoa Point at Lahaina).

[Table 7] provides the maximum erosion and accretion rates for each region on the Island of Maui in both the long and short term.

Island of Maui PDT Meeting

The Island of Maui PDT met on 25 September 2012 to discuss needs and opportunities to implement RSM activities. Key topics by USGS-defined region discussed at the meeting include the following.

North Maui Region

Kahului Deep Draft Harbor

The Harbor is scheduled to be dredged in FY15. Based on the quality of material to be dredged, there is a possibility the dredged material could be placed on Kanaha Beach east of the project area. There is a need to begin coordinating RSM activities in association with this dredging opportunity.

[1] This section (West Maui Region) was extracted verbatim from Fletcher et al. 2012, by permission.

Figure 21. Long-term (all available years) and short-term (1940s to present) shoreline change rates, West Maui (location shown in Figure 18) (Figure 38 of Fletcher et al. 2012; by permission).

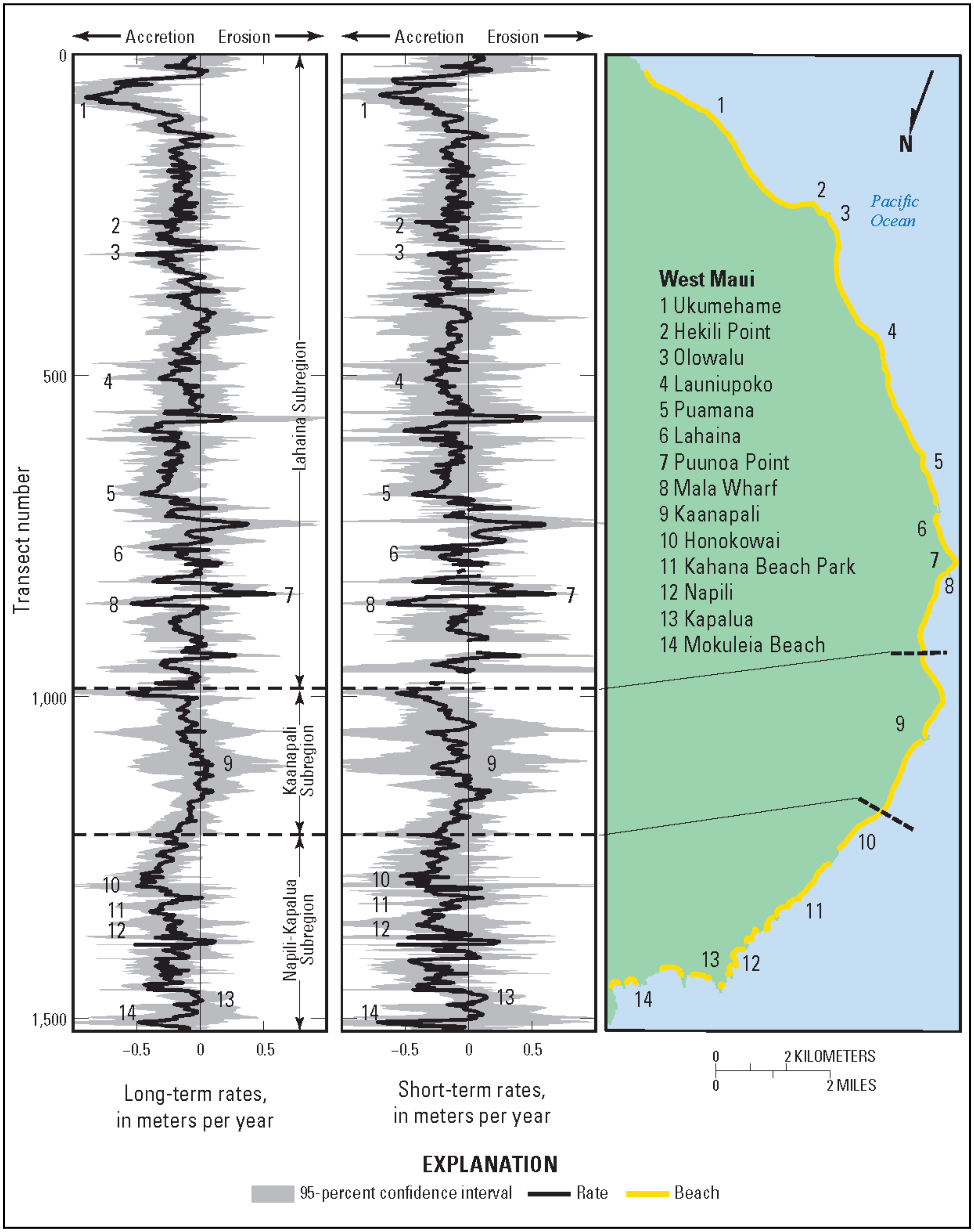


Table 7. Maximum shoreline change rates on Maui (Table 13 of Fletcher et al. 2012; by permission).

Region	Long-term rate (m/yr)	Location[1]	Short-term rate (m/yr)	Location[1]
		North		
Max. erosion	-1.5 ± 1.1	Baldwin Park, sand mining[2]	-2.2 ± 1.1	Baldwin Park, sand mining[3]
Max. accretion	1.5 ± 1.3	Kanaha Beach Park, groins	2.1 ± 0.2	Kanaha, groins[2]
		Kihei		
Max. erosion	-1.1 ± 0.6	Kawililipoa, within fishpond remains	-1.8 ± 7.5	Kalepolepo Beach Park, beach lost
Max. accretion	1.6 ± 0.4	Kawililipoa, accretional cusp[2]	1.8 ± 0.5	Kawililipoa, accretional cusp
		West		
Max. erosion	-0.9 ± 0.6	Ukumehame, coastal road revetment	-0.7 ± 1.7	Kapalua, Mokuleia Beach, variable
Max. accretion	0.6 ± 0.2	Lahaina, Puunoa Point	0.7 ± 0.2	Lahaina, Puunoa Point

[1]Locations shown in Figures 19–21.

[2]Maximum erosion or accretion for Maui.

[3]Maximum erosion or accretion for three islands (Kauai, Oahu, and Maui).

Maui County may consider being the non-federal sponsor for incremental additional cost. There is a large deposit of sediment offshore of Kahului Harbor, but it may be in water too deep for a hopper dredge to reach.

Baldwin Beach

There previously was extensive sand mining conducted at Baldwin Beach. The sub-region has a high shoreline retreat rate. This would be an informative RSM study area.

Manpokuji Bay

Shoreline property owners are proposing to build a revetment. The County of Maui would like the owners to consider soft solutions to the problem. The Bay is a littoral cell with no exchange of sediment around the headlands that make up the cell. Any fill that is placed within the cell would be relatively stable in the long term. This indicates favorable coastal processes for a soft solution versus hardening of the shoreline.

Sugar Cove

A recent beach nourishment project at Sugar Cove resulted in the placement of a few thousand cubic yards of sand and construction of three geotube groins. The Sugar Cove residents have applied for a permit to remove the three geotubes and replace them with rubble-mound groins. There is no additional beach fill being proposed. RSM investigations on the use of groins to induce shoreline stability are needed.

Kihei Maui Region

North Kihei

The coastal road is threatened by shoreline retreat along a lengthy portion of North Kihei. The DOT's only solution for road protection is currently shoreline hardening (revetments, pile dikes, and dumped rock). Offshore structures may be the key to keeping the beaches stable.

Kalama Beach

An existing POH revetment at Kalama Beach may be impacting the adjacent shoreline to the north. Flanking of the revetment is indicated by extensive shoreline recession which threatens a number of houses to the north. The County of Maui and State of Hawaii are concerned about the flanking trend and would like POH to investigate cause and effect of the federal project on the shoreline retreat.

West Maui Region (Kaanapali through Honolua Bay)

At the request of the Hawaii RSM non-federal sponsor (and with concurrence from Maui County personnel), the West Maui Region is the focus of FY14 RSM studies. The region was chosen for detailed RSM investigations due to its economic importance, beach erosion problems currently being experienced, and issues associated with implementation of the various shore protection measures being proposed.

Contact should be established with the Kaanapali Operators Association to discuss the Sea Engineering study results.

Hololani

Temporary shore protection measures have been installed adjacent to a condominium in Hololani. The condominium association has requested a permit to remove the temporary features and harden the shoreline. Coastal engineering analyses provided by the association predict that a stable sand beach will accrete seaward of the structure. The County of Maui is concerned that this will be another case where sandy shoreline will be lost to the public domain.

Island of Maui PDT RSM General Comments

Sand is not recognized as a mineral by the State of Hawaii, and therefore neither its sale, use, nor transport is regulated by State or County policy.

Maui County needs to stockpile sand until such time that it can be used for beach nourishment.

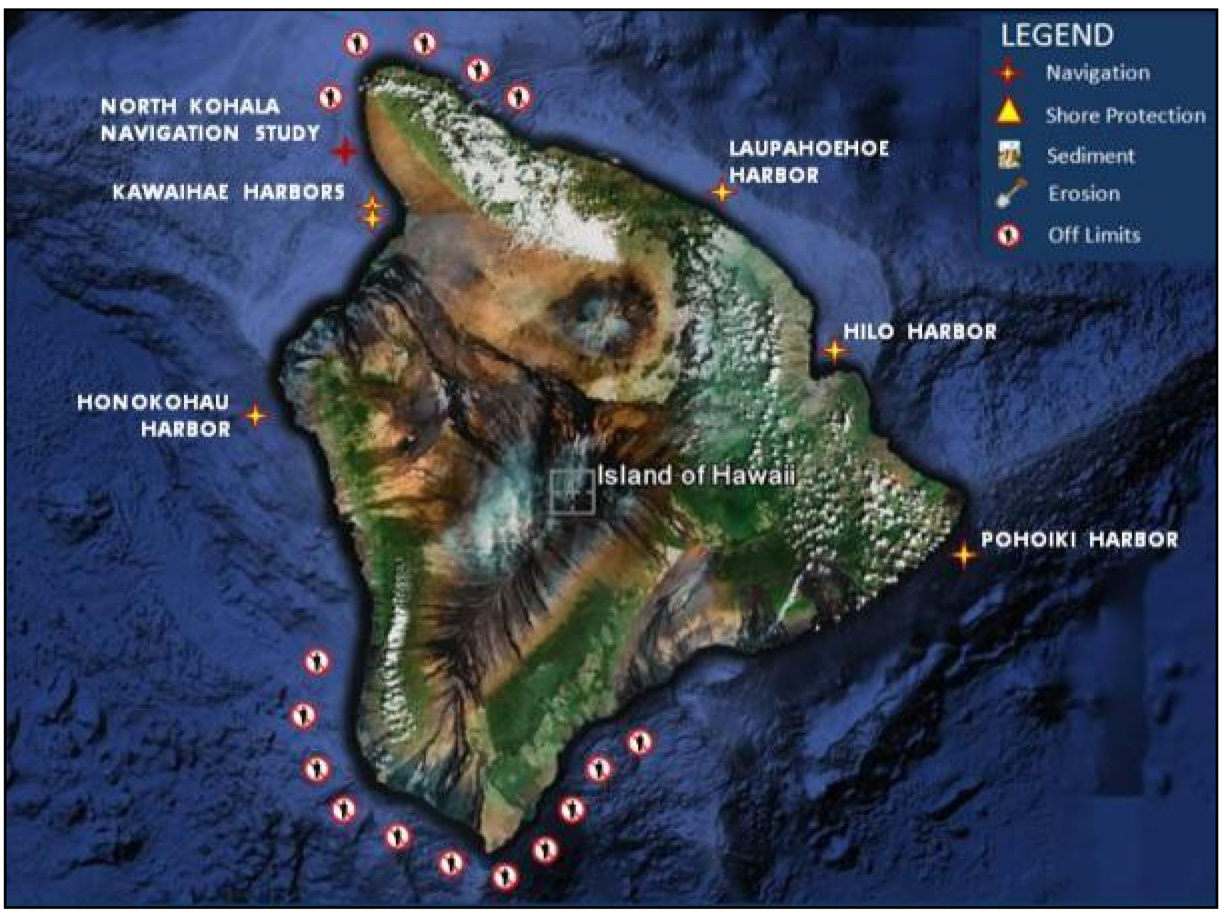
Maui County staff recommended that lessons learned from the recent Waikiki Beach be documented and reviewed so they can be incorporated into future beach renourishment activities.

Maui County is processing an ever-increasing number of permits to harden shorelines. The County feels that there is a need to develop alternatives to hardening since those types of alternatives remove beaches from the public domain.

5 Island of Hawaii

The Island of Hawaii is 93 miles across in its greatest dimension and has a land mass of 4,028 sq miles. Measured from its sea floor base to its highest peak, Mauna Kea is the world's tallest mountain, taller than Mount Everest is above sea level. Figure 22 displays federally authorized projects in Hawaii County that could potentially benefit from implementation of RSM principles and practices. Areas that could potentially be used as sediment sources, areas of chronic erosion, and portions of the shoreline that may be off limits to RSM activities are also indicated.

Figure 22. Locations of federally authorized navigation projects (stars) on Island of Hawaii that could potentially benefit from RSM activities.



The federally authorized studies and projects of interest on the Island of Hawaii include (a) Hilo Deep Draft Harbor, (b) Kawaihae Deep Draft Harbor, (c) Kawaihae Small Boat Harbor, (d) Honokohau Small Boat

Harbor, (e) Laupahoehoe Navigation Improvements, (f) Pohoiki Navigation Improvements, and (g) North Kohala Navigation Study.

Dredging History

Federal navigation dredging on the Island of Hawaii has been limited to initial construction for all harbors except Hilo Deep Draft Harbor and Kawaihae Harbor (Table 8). Hilo Harbor was dredged in 1977 and 1990 with volumes dredged of 54,118 cy and 80,000 cy, respectively. Unit costs of material dredged ranged from $1.92/cy in 1997 to $3.59/cy in 1990. Kawaihae Harbor has been dredged once since initial construction. Approximately 25,000 cy of material were dredged from the harbor in 1973 at a unit cost of $2.47/cy. There is no evidence that any of the dredged material was used beneficially.

Table 8. Summary of federally authorized navigation project dredging on Island of Hawaii.

YEAR	ISLAND	PROJECT	VOLUME [cy]	COST [$]	UNIT COST [$/cy]
1990	HAWAII	HILO HBR	80,000	$286,855	$3.59
1977	HAWAII	HILO HBR	54,118	$104,130	$1.92
1973	HAWAII	KAWAIHAE DDH	25,000	$61,800	$2.47

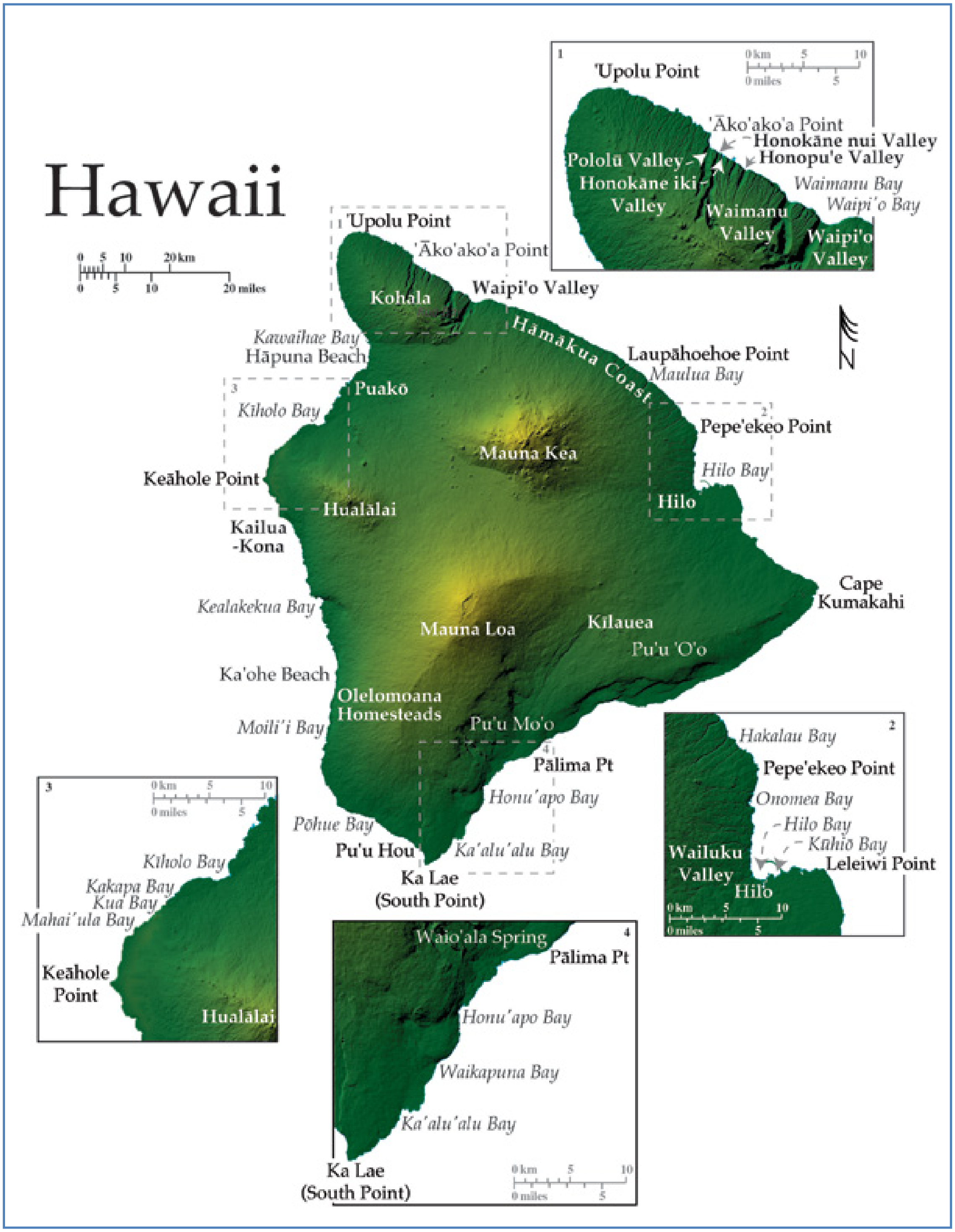
Shoreline Change

The USGS report *National Assessment of Shoreline Change; Historical Shoreline Change in the Hawaiian Islands* (Fletcher et al. 2012) does not include data for the Island of Hawaii. The following description of beaches on the Island of Hawaii was reproduced verbatim by permission from the website of the University of Hawaii at Manao, School of Ocean and Earth Science and Technology, Coastal Geology Group (UH CGG 2012).

The Island of Hawai‘i lies over or just north of the Hawaiian [volcanic] hot spot and is composed of five volcanoes and one active seamount: Kohala, Hualālai, Mauna Loa, Kïlauea, [and] Mauna Kea [volcanoes], and Loihi [seamount] located offshore [Figure 23]. Of these, only Mauna Loa, Kïlauea, and Loihi are considered active, while Haulālai is dormant with its most recent eruption ending sometime in 1800–1801. The Island has 428 km of general coastline and is so large relative to the other Hawaiian Islands, it is known locally and abroad as the Big Island.[1]

[1] This paragraph was extracted verbatim from UH CGG 2012, by permission.

Figure 23. Island of Hawaii map with insets showing locations of various points of interest discussed in the narrative (uncaptioned figure of UH CGG 2012; by permission).



On the Big Island, well-developed black and green sand beaches signify the active reworking, by waves and currents, of the freshest lavas in the state. The island's youth has, in general, allowed for a lower degree of beach formation along its rough volcanic coastline. White calcareous beaches make up a relatively small component of the shoreline largely because of poor reef development due to recent active coastal volcanism.[1]

The orographic effect of the Big Island's large shields creates a lush region on the northeast side of the Big Island, where annual rainfall is between 150 and 400 centimeters (cm). The highest peak on Mauna Loa is 4,169 m, while Mauna Kea and Kohala are 4,205 m and 1,670 m, respectively.[1]

The roughly triangular-shaped Island of Hawaii can conveniently be divided into three coastal regions: (a) Northeast Hawaii Region, (b) West Hawaii Region, and (c) Southeast Hawaii Region.

Northeast Hawaii Region[2]

The Puna District comprises the eastern most corner of the Big Island, reaching out at Cape Kumakahi, a broad, rocky point with a shallow slope at the coast [Figure 24]. This area was resurfaced during the 1960 flow originating from Kïlauea's east rift zone. The flow narrowly missed the navigational light on the point as it remarkably divided into streams and flowed around the lighthouse (Clark 2002).

North of Cape Kumukahi the coast extends for roughly 25 km around Leleiwi Point into the Hilo District and Hilo Bay in a series of wave weathered low rocky sea cliffs, and rough remnant lava flows. Hilo Harbor is one of two deep draft harbors on the Big Island [Figure 25].

Kawaihae Harbor (located on the northwestern coast) is the other. The Bay is the seaward end of the Wailuku River Valley that runs along the junction between the younger Mauna Loa lavas to the south and older Mauna Kea lavas to the north. A breakwater 3.0 km long extends offshore from a large natural deepwater gap in the fringing reef of Kühiö Bay. The structure runs west in front of the developments fronting eastern and central Hilo Bay. Hilo is a heavily populated coastal city that was devastated in both 1949

[1] This paragraph was extracted essentially verbatim from UH CGG 2012, by permission.

[2] This section (Northeast Hawaii Region) was extracted essentially verbatim from UH CGG 2012, by permission.

Figure 24. Cape Kumakahi, a broad, rocky point with a shallow slope at the coast (uncaptioned figure of UH CGG 2012; by permission).

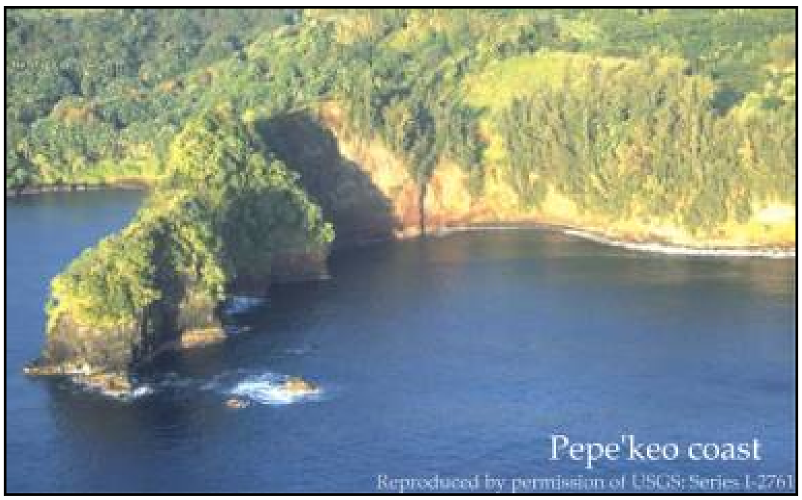
Figure 25. Hilo Harbor breakwater and berthing areas, Island of Hawaii. The Hilo Small Boat Harbor is also visible in the upper left portion of the photograph (uncaptioned figure of UH CGG 2012; by permission).

and 1960 by tsunamis originating from earthquakes in the Aleutian trench and along the Chilean coast, respectively (Fletcher et al. 2002). In 1984, Mauna Loa broke a nine-year period of quiescence sending lava flowing down to the northern city limits, a reminder of the volcanic hazard in this coastal city (Fletcher et al. 2002).

The Pepe‘ekeo-Hämäkua Coast stretches for 100 km between Hilo and Waipi‘o Valley to the north. This northeast and northern exposed coastline consists of a steep rocky shoreline of Mauna Kea lavas, characterized by a multitude of headlands, sea cliffs (~30-90 m high), coves, and irregular embayments such as Onomea, Hakalau, and Maulua Bays. The Hämäkua

coastal embayments are seaward ends of stream carved gulches that originate upland on the lush Mauna Kea mountainside, and are a passage to the coast for water rich with sediment, soil, and eroded volcanic rock. Black volcanic pebble and cobble stone beaches line the Bay heads, and large blocks of fluvially transported basaltic debris along the shoreline lie where they have been scattered by high-energy waves. No fringing reef has developed along this relatively young shoreline; however, offshore rocky islets are commonplace along the northeast coasts of the Big Island, totally exposed to north Pacific tradewind seas [Figure 26].

Figure 26. An example of a typical offshore rocky islet located along the Pepekeo coast (uncaptioned figure of UH CGG 2012; by permission).

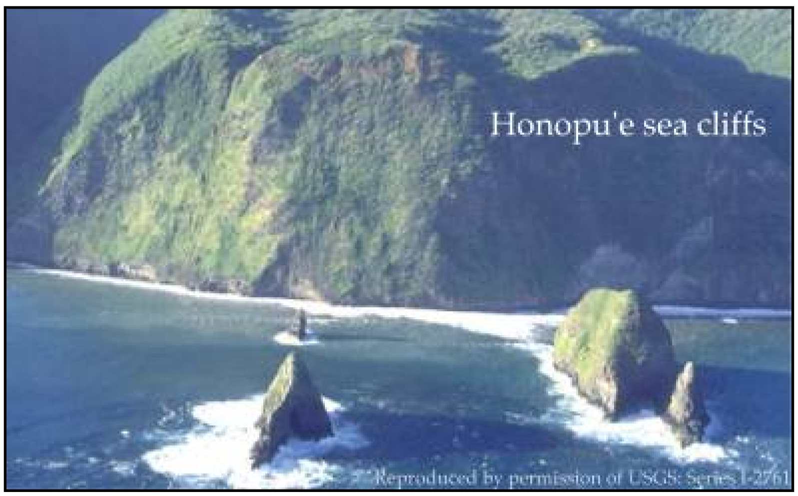


Waipiʻo Valley, in the far northeast, marks the junction where Mauna Kea lavas to the south overlie lavas of the broad and elliptical Kohala Volcano (1,670 m) to the north. Kohala is the Big Island’s oldest shield, projecting northwestward and forming the northernmost portion of the Island. Waipiʻo Valley is the first, and most immense (approximately 1 km wide), of seven spectacular shore-normal amphitheater valleys that extend northwest along the Kohala coast. These valleys developed during a lower stand of the sea (~90 m), and were partly filled with alluvium at that time. As sea level rose, the alluvium was reworked, and the modern low lying, scenic wetland valley floors that lie inland of the coast were created (MacDonald et al. 1986).

The valleys such as Waimanu, Honopuʻe, Honokäne Nui/Iki, and Pololü are bordered by steeply ascending massive rock walls [Figure 27]. Except for a four-wheel-drive road into Waipiʻo, access to the lush valley floors is limited to foot trails or boats. Dynamic beaches dominated by black

volcanic sand line the seaward end of the northeast Kohala valleys. Between the largest of the amphitheater valleys, the coast is dominated by blunt sea cliffs that rise to 400 m above the ocean, the truncated remains of the shield that once extended at least a kilometer into the ocean. The cliffs are incised by numerous stream cut canyons 300 to 750 m deep that form a series of narrow coastal hanging valleys (MacDonald et al. 1986). This area represents the only coastal segment of Kohala that was spared resurfacing by the Hawi Volcanic Series toward the end of the Kohala main shield building stage when Hawi lavas flowed over most of the eroding shield (MacDonald et al. 1986).

Figure 27. Sea cliffs are numerous along the Honopue coast (uncaptioned figure of UH CGG 2012; by permission).



Akoakoa Point [Figure 28] lies north of Pololü Valley where the east Kohala coastline is made up of steep lava headlands and irregular low lying rocky embayments where streams enter the ocean out of wetland gulches. Like the shoreline to the south, small rocky sea stacks lie offshore of eastern Kohala, isolated from the retreating coast by heavy North Pacific surf (Fletcher et al. 2002). This coastal morphology, with the addition of sparsely distributed cobble and boulder beaches, extends from the exposed northern tip of the Island at Upolu Point around to Kawaihae Bay and Harbor at the western intersection of the Kohala and Mauna Kea shields.

West Hawaii Region[1]

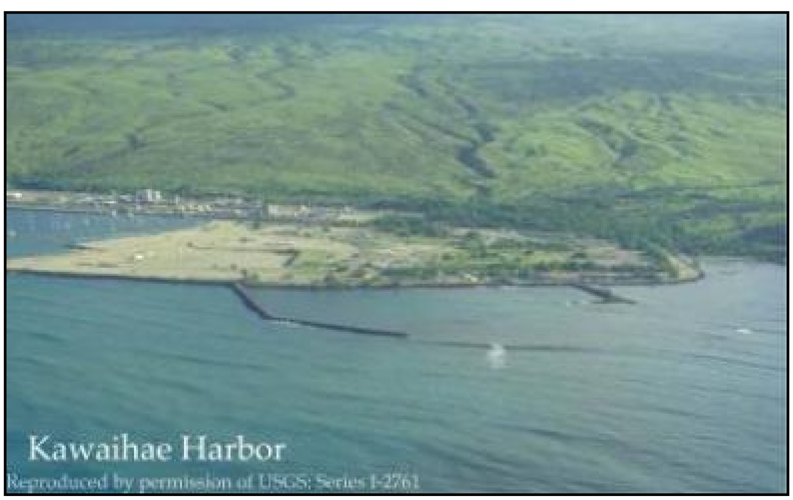
The western side of the Big Island lies in the lee of Mauna Loa (4,205 m), the largest volcano on Earth (measured from the sea floor), which has

[1] This section (West Hawaii Region) was extracted verbatim from UH CGG 2012, by permission.

formed in the last 600,000 to 1,000,000 years, rising almost 9 km from the sea floor. The leeward climate is extraordinarily dry with 25 centimeters (cm) annual rainfall, and minimal stream erosion on the Hawi lavas of western Kohala, and on the lavas of Mauna Kea, Mauna Loa, and Hualälai, south along the coast, respectively. Kawaihae Harbor is the second deep draft harbor on the Big Island, and is fronted by a system of offshore fringing reefs [Figure 29]. Several sand beaches exist at the south end of Kawaihae Bay, derived from eroded coral that was dredged during construction of the Harbor.

Figure 28. Akoakoa Point extends offshore on the east Kohala coastline just north of Pololu Valley (uncaptioned figure of UH CGG 2012; by permission).

Figure 29. Kawaihae Small Boat Harbor (pictured in the foreground) is located adjacent to Kawaihae Deep Draft Harbor (uncaptioned figure of UH CGG 2012; by permission).



Approximately 5 km south of Kawaihae, along a shoreline of bright golf course greens and hotel development, lies Häpuna Beach, the widest of the few well-developed calcareous sand beaches on the Big Island. The Puakö coast lies just south of Häpuna Beach, along the coast that was extended by historic Mauna Loa eruptions. Renowned for its tide pools at the shoreline and well-developed offshore fringing reef, the Puakö coast is a popular scuba dive destination.

Hualälai Volcano (2,521 m) makes up the central western coast of the Big Island. Now a dormant volcano, it last erupted in 1800–1801, burying an ancient Hawaiian village along the northwest coast. From the western banks of the shallow coastal lagoon at Kïholo Bay, the Hualälai coast extends southwest and is rocky and shallow sloped. Offshore fringing reef and pocket sandy beaches line the numerous embayments including Kakapa, Kua, and Mahaiʻula Bays along this coast.

Lavas of the most recent Hualälai eruptions make up the coast from the south side of Mahaiʻula Bay to the western tip of the Island at Keähole Point. This shoreline is characterized by low rocky headlands fronted by fringing reef, small rocky remnants offshore, and beautiful tide pools and beaches (both black and white) along the shore. The coastline of historic Hualälai lava extends less than 30 km south of Keähole Point, beyond Kailua-Kona to the small non-distinct west facing Kuamoʻo Point. Lavas of the southwest Mauna Loa rift zone extend beyond Kuamoʻo Point to the south point of the Island. The South Kona district has a coastline rich with relics of historic Hawaiian habitation. Much of this coast is low-lying historic lava that has been gradually invaded by hardy vegetation. In contrast, Kealakekua Bay is an area along this coast that contains steep cliff walls that reveal the layered nature of their basalt [Figure 30]. The Bay is accessible only by boat or foot trail and harbors one of the State's underwater parks. This 315 acre marine conservation district is lined with a vibrant healthy reef ecosystem (Clark 2002). Abundant fish swim about the shallow corals that dip steeply away from shore toward deeper water. The Bay is the location where Captain Cook moored for reprovisioning, and ultimately his death.

Between Kaʻohe and Moiliʻi, streaks of relatively recent flows (1950's) extend to the coast from the volcano [Figure 31]. Here, tide pools at the shoreline are generally formed of lava spits in various stages of erosion. These areas are mainly accessible by four-wheel-drive off-road vehicles, and are devoid of development.

Figure 30. Kealakekua Bay is an area along this coast that contains steep cliff walls that reveal the layered nature of their basalt (uncaptioned figure of UH CGG 2012; by permission).

Figure 31. Recent lava flow remains mostly un-vegetated near Kaohe (uncaptioned figure of UH CGG 2012; by permission).

Because of its relative youth, the Mauna Loa coastal terrace of the southwest coast has lower degrees of soil development. In its absence, subsurface streams fed by upland precipitation penetrate the relatively young porous basalt. These conditions have created a system of sub-surface fresh water flows that feed wetlands and offshore freshwater seeps along the southwest coast of the Big Island from Miloliʻi to Ka lae Point. The shoreline from Moiliʻi to Ka lae Point is made up of shallow and moderately sloped headlands and low sea cliffs, and is backed by numerous wetlands areas fed by the underground freshwater flows. Beaches of the southwest coast are almost exclusively black sand. Several cones of cinder and ash lie just inland of the southwest shore and were built by littoral explosions during historic

sea entries of Mauna Loa lavas (MacDonald et al. 1986). The most recent flows of 1868 produced Puʻu hou, a cinder cone rising 72 m from the shoreline. Wave erosion has truncated the cone, resulting in a beach of red cinder at its base. Olivine sand beaches skirt the rocky headland coasts of south Hawaiʻi produced by the fresh erosion of the Island's basalt.

Southeast Hawaii Region[1]

Extending north from Ke lae Point, the southeast coast is made up of steep rocky headlands that transition to a low-lying coastal plain in the region of Honuʻapo Bay. This geologically complicated area has been impacted by historic tsunamis and general tectonic subsidence. The Kïlauea southwest rift zone cuts through the coastline into the seafloor several kilometers northeast of Waioʻala Spring, at Pälima Point, marking the end of the wetland areas of south Mauna Loa and signaling the start of the Kïlauea coastline.

Kïlauea Volcano is a large bulge on the southeast flanks of Mauna Loa although it is an independent volcano with its own magma plumbing system. This volcano has been consistently active since at least the early nineteenth century, if not since its emergence above sea level, continuously creating and redefining the coastal areas along east and southeast sides of the Big Island. On May 12th 2002, the Mother's Day Flow commenced on the south flank of Kïlauea after issuing from a new vent near the southwest base of Puʻu ʻöʻö cone, 8 km upslope from the south east coast. As is typical of Kïlauea flows, the Mother's Day Flow traveled as molten lava through preexisting lava tubes down the south flank of the volcano to the coastal plains. By late July 2002, two arms of the flow had reached the ocean, forming a broad lava delta that runs 570 m along the coast extending 50 m offshore of the West Highcastle coast, and a 1,540 ft wide lava bench that extends more than 300 ft offshore at Wilipea.

Lava benches such as at Wilipea are a mechanism of the Island's growth. These form as lava builds up repeatedly into thick and wide benches at the coast [Figure 32]. Lava benches may collapse suddenly into the ocean, leaving behind sharp cliffs, and creating steam plumes of lava haze as seawater boils and vaporizes on contact with the rocks that may be hotter than 1,100° C. These collapses may release water vapor, sulfur dioxide, chlorine gas, and fine shards of volcanic glass. Activity at the surface of

[1] This section (Southeast Hawaii Region) was extracted verbatim from UH CGG 2012, by permission.

Kïlauea reflects the dynamics at depth within the magma chamber that are recognized as earthquakes on the surface. They may mark movement of the south flank, as it shifts steadily seaward at a rate of about 8-10 cm/yr (Morgan et al. 2000).

Figure 32. Steam rising as lava enters the ocean from the Kilauea flow (uncaptioned figure of UH CGG 2012; by permission).

Island of Hawaii PDT Meeting

The Island of Hawaii PDT met to discuss needs and opportunities to implement RSM activities. Key topics discussed at the meeting included the following.

Northeast Hawaii Region

Waipio Valley

County staff indicated that large volumes of sediment were introduced into the Waipio Valley stream as a result of the 2006 earthquake. Sand bars form in the river now and back-up stream flows onto adjacent taro fields. Excess water in the fields is impacting the quantity and quality of the harvested taro. This has become a significant sediment management problem since the 2006 earthquake. The stream mouth is typically plugged with sand, rock, rubble, and large basalt boulders. It is important to investigate inclusion of Waipio Valley as an Engineering With Nature initiative.

The Natural Resources Conservation Service has developed a stream maintenance plan to deal with various aspects of the problem. The purpose of the Waipio Stream Management Plan is to assist Waipio Valley taro farmers and residents with maintaining the streams in the Waipio

Valley and help them successfully operate in a traditional manner but within the constraints of modern law and society. The plan addresses stream activities and the permits and approvals necessary to conduct stream maintenance activities for the protection of the property and livelihood of the residents of Waipio Valley. In addition, the plan also strives to help maintain aquatic habitat for native organisms and preserve the cultural heritage of the Waipio Valley. The management plan was developed in a holistic manner with the idea that traditional and customary practices should be preserved, including the traditional taro-growing water management system led by watershed leaders.

Wailoa Boat Harbor

The Wailoa Boat Harbor is owned by the State of Hawaii, Department of Boating and Ocean Recreation. During a recent maintenance dredging of the Harbor, the dredged material was trucked from the site to unknown locations. Hawaii County staff would like to investigate putting the sediment dredged from the harbor along the adjacent shoreline.

Hilo Harbor

The Hilo Harbor breakwater is nearly 2 miles long and affects the circulation within the Bay. Modification of the breakwater is recommended by County staff to improve circulation and ultimately water quality within the Bay. Future deepening of various channels and berthing areas in Hilo Harbor are being considered. Additionally, POH plans to conduct maintenance dredging at all deep-draft harbors in the State that are below project depth in FY15. Material dredged during these and other operations should be considered for beneficial use.

West Hawaii Region

Puako Boat Ramp

The boat ramp is owned and operated by the State of Hawaii, Department of Boating and Outdoor Recreation. The facility is located approximately 31 miles from Kailua-Kona and includes a single 16 ft-wide boat ramp, loading dock, pier, and vessel wash-down area. County staff indicated that there are sediment shoaling problems being experienced at the ramp.

Kawaihae Deep Draft Harbor

POH plans to conduct maintenance dredging at all deep-draft harbors in the State in FY15. Material dredged during this and other operations should be considered for beneficial use.

Pelekane Bay

Long-term changes in the marine habitat and biota of Pelekane Bay were studied over a 20 yr period from 1976 through 1996 (Tissot et al. 2009). A major decline in the abundance of the marine biota has taken place. Possible causes of this deleterious change were associated with long-term sedimentation due to terrestrial runoff from the Kawaihae watershed and reduced ocean circulation in Pelekane Bay caused by construction of the deep- and shallow-draft harbors. County staff feels that further investigation of sedimentation issues at Pelekane Bay is warranted.

Southeast Hawaii Region

Punaluu County Beach Park

County staff has concerns about the stability of the black sand beach located within the beach park property.

6 Summary, Conclusions, Recommendations, and Hawaii Regional Sediment Management (RSM) Priorities

Summary

Background

RSM was officially implemented at the USACE Pacific Ocean Division, Honolulu District, Honolulu, Hawaii (POH), in February 2004. The overall POH RSM strategy is to investigate RSM opportunities along all regions in Hawaii. To date, Hawaii RSM has been instrumental in quantifying coastal processes and identifying sediment related issues in various regions on Island of Oahu (Mokapu Point to Makapuu Point, and Diamond Head to Pearl Harbor), Island of Kauai (Poipu and Kekaha), and Island of Maui (Kahului and Kihei). In addition to identification and prioritization of future RSM efforts on these Islands, POH RSM will also investigate opportunities to conduct RSM activities on the Island of Hawaii.

The U.S. Department of the Interior, U.S. Geological Survey (USGS), also recognizes that beach erosion is a chronic problem along most open-ocean shores of the United States. USGS has contracted with the University of Hawaii (UH) at Manoa, School of Ocean and Earth Science and Technology, Coastal Geology Group (CGG), to conduct an assessment of shoreline change on three of the main Hawaiian Islands (Kauai, Oahu, and Maui) (Fletcher et al. 2012). http://pubs.usgs.gov/of/2011/1051/pdf/ofr2011-1051_report_508_rev052512.pdf

The UH CGG is an affiliation of researchers, technicians, and graduate students within the Department of Geology and Geophysics that conducts investigations of shoreline change, carbonate geology, reef geology, sedimentology, and coastal morphodynamics. UH CGG seeks to improve understanding of coastal change through time, requiring research investigation on a range of spatial and temporal scales. UH CGG provides a description of beaches on the Island of Hawaii (UH CGG 2012) at the web site http://www.soest.hawaii.edu/coasts/publications/hawaiiCoastline/hawaii.html.

Because of the inherent critical interest of these three coastal sediment aligned organizations (USACE, USGS, and UH CGG) regarding the State of Hawaii coastal zone, conclusions by these agencies are incorporated into this one USACE Technical Report (TR), thus providing a comprehensive review of sedimentation along the coastlines of the Hawaiian Islands of interest. In this TR, pertinent sections of the USGS Open-File Report 2011-1051, *National Assessment of Shoreline Change: Historical Shoreline Change in the Hawaiian Islands* (Fletcher et al. 2012) pertaining to the Islands of Kauai, Oahu, and Maui are extracted verbatim by permission. Pertinent sections from the UH CGG website (UH CGG 2012) pertaining to the Island of Hawaii are also extracted verbatim by permission.

Approach

Federally authorized projects of interest on each of the main Hawaiian Islands shown in Figure 1 (Islands of Kauai, Oahu, Maui, and Hawaii) are identified, and the dredging history of each is presented. Shoreline change for Islands of Kauai, Oahu, and Maui are presented as quantified by the USGS (Fletcher et al. 2012). Shoreline change rates were calculated from long-term and short-term shoreline data. All available shorelines were used for long-term rate calculations, and post-WWII shorelines were used for short-term rate calculations. A minimum of three historical shoreline positions was required when calculating a shoreline change rate with the technique employed by the USGS. Figures from Fletcher et al. (2012) graphically depicting shoreline change by sub-region for each of these three islands are provided, by permission. A description of the beaches on the Island of Hawaii as developed by UH CGG (2012) is also provided, by permission.

Opportunities to implement RSM activities are documented and prioritized by island based on input from the Hawaii RSM Project Delivery Team (PDT). The PDT consists of POH staff; the State of Hawaii Department of Land and Natural Resources, Office of Conservation and Coastal Lands; County staff; and various stakeholders.

Conclusions

Island of Kauai

North Kauai Region

In the short term, the highest rate of shoreline recession (up to -1.0 m/yr) has occurred in the Kauapea sub-region. Sub-regions that have experienced shoreline advance on the order of 0.5 m/yr include Kahili, Hanalei, and Lumahai. The remainder of the region's shoreline has been relatively stable in the short term.

East Kauai Region

Kuaehu Point is experiencing the largest rate of shoreline recession within the region. The average shoreline recession in this sub-region is approximately -0.75 m/yr while the central portion of the sub-region is experiencing a recession rate of -1.5 m/yr. Shoreline advance has occurred in the short term in the Waipoli and Anahola sub-regions. Shoreline change within the remainder of the region generally varies from 0.5 to -0.5 m/yr.

South Kauai Region

Shoreline advance dominates along the entire sub-region with an average rate of 0.75 m/yr and maximum of 1.50 m/yr. East of the Waimea River, the shoreline is generally stable through Koki Point. At that point, the shoreline is receding at a rate of over -1.0 m/yr. The shoreline is slightly recessional through the remaining sub-regions of Poipu, Shipwreck, and Mahaulepu Bay.

West Kauai Region

In the short term, shoreline advance dominates in the region. Significant areas of shoreline advance are documented at the northern limit of the Polihale sub-region (2.0 m/yr) and Majors Bay (2.0 m/yr). The shoreline recession signal decreases westward from Kikiaola Harbor starting at a rate of 0.75 m/yr near the harbor to nearly 0.00 m/yr at the boundary between the Oomano and Majors Bay sub-regions.

Island of Oahu

North Oahu Region

The maximum long-term erosion rate (-1.3 ± 0.8 m/yr) was found at Haleiwa Beach Park at a segment of shoreline behind a small breakwater where the beach has been lost. This beach has undergone substantial modification throughout its history. The maximum long-term accretion rate (0.8 ± 0.8 m/yr) was measured at Rocky Point in the Sunset sub-region.

East Oahu Region

More transects are erosional in the short term than in the long-term rates, with erosion occurring at 54% of transects and accretion occurring at 44%. The beach at central Lanikai is accreting at up to 0.8 ± 0.3 m/yr; however, the beach along the adjacent shoreline to the north and south has been lost to erosion (seawalls) in the last few decades.

South Oahu Region

Nourishment of Waikiki Beach has continued since the early 20^{th} century into the 21^{st} century, with the most recent nourishment project occurring in early 2012 (24,000 sq yd).

The maximum long-term erosion rate (-1.6 ± 2.7 m/yr) was found at Queens Beach, Waikiki, where the shoreline is hardened, and much of the beach disappeared prior to 1975. Erosion up to -1.6 ± 0.4 m/yr is also occurring at the eastern end of the Ewa sub-region near the Pearl Harbor entrance channel (Keahi Point). The maximum long-term accretion rate (0.8 ± 0.2 m/yr) was found at Kaimana Beach in Waikiki. The maximum short-term erosion and accretion rates were measured at the same locations as the maximum long-term erosion and accretion rates, respectively (Kaimana and Queens, Waikiki).

West Oahu Region

West Oahu is the most erosional region of the Island, with an average long-term rate of -0.25 ± 0.01 m/yr and 83% of transects indicating erosion in the long term. The maximum long-term erosion rate (-1.2 ± 0.5 m/yr) was found in the northern part of Maili Beach. The maximum accretion rate (1.7 ± 0.6 m/yr) was found in the southern part of Pokai

Bay. The short-term rates at Yokohama, Keaau, and Maili are less erosive than the long-term rates, indicating that shoreline recession may have slowed since sand-mining operations ceased.

Maui County

Maui's beaches are the most erosional among the three Islands (Kauai, Oahu, and Maui) investigated by the USGS (Fletcher et al. 2012). Average shoreline change rates for all analysis regions and sub-regions are erosional. The average long-term rate for all transects is -0.17 ± 0.01 m/yr and the average short-term rate is -0.15 ± 0.01 m/yr.

North Maui Region

The maximum erosion rate (-1.5 ± 1.1 m/yr) was found in front of an offshore rock bench at Baldwin Park. Other areas of significant erosion were found at Waiehu Beach Park (up to -0.5 ± 0.3 m/yr, long term) and Kanaha Beach Park (up to -1.5 ± 0.7 m/yr, long term). The maximum long-term accretion rate (1.5 ± 1.3 m/yr) was measured between two groins at Kanaha Beach Park.

The average short-term shoreline change rate for North Shore beaches, -0.22 ± 0.03 m/yr, is roughly the same as the average long-term rate. The maximum short-term erosion rate (-2.2 ± 1.1 m/yr) was found in the same location as the maximum long-term erosion rate (Baldwin Park). The maximum short-term accretion rate (2.1 ± 0.2 m/yr), like the maximum long-term accretion rate, was found in Kanaha Beach Park.

Kihei Maui Region

The maximum long-term erosion rate (-1.1 ± 0.6 m/yr) was found at Kawililipoa. Other areas with substantial long-term erosion include South Wailea (up to -0.5 ± 0.2 m/yr), North Wailea (up to -0.4 ± 0.2 m/yr), Kalama Park (up to -0.8 ± 0.5 m/yr; beach lost), and Maalaea (up to -0.6 ± 0.2 m/yr). The maximum long-term accretion rate (1.6 ± 0.4 m/yr) was also found at Kawililipoa, along an accretional cusp.

The average short-term rate is -0.12 ± 0.02 m/yr, and 77% of the short-term rates are erosional. The maximum short-term erosion rate (-1.8 ± 7.5 m/yr) was found at Kalepolepo Beach Park, where the beach has been completely lost to erosion. The maximum short-term accretion rate was

found at the same location as the maximum long-term accretion rate (Kawililipoa, 1.8 ± 0.8 m/yr). Long- and short-term rates have similar overall trends.

West Maui Region

The average of all long-term rates for West Maui is -0.15 ± 0.01 m/yr, and 85 % of transects are erosional in the long term. All sub-regions in West Maui are erosional in the long and short term based on average rates. The Napili-Kapalua sub-region has the highest average erosion rates, -0.22 ± 0.02 m/yr in the long term and -0.19 ± 0.03 m/yr in the short term. The maximum erosion rate (-0.9 ± 0.6 m/yr) was found at Ukumehame adjacent to a boulder revetment installed to protect the coastal highway. Other areas of significant long-term erosion include Hekili Point (up to -0.3 ± 0.2 m/yr), Olowalu (up to -0.3 ± 0.2 m/yr), Launiupoko (up to -0.5 ± 0.3 m/yr), Puamana (up to -0.5 ± 0.2 m/yr), Mala Wharf (up to -0.5 ± 0.4 m/yr), Honokowai (up to -0.5 ± 0.4 m/yr), Kahana (up to -0.4 ± 0.1 m/yr), and Napili Bay (up to -0.4 ± 0.2 m/yr)

Erosion at West Maui is slightly lower in the short-term than in the long-term rate, with an average short-term rate of -0.13 ± 0.01 m/yr, and 77% of transects are erosional. The maximum short-term erosion rate (-0.7 ± 1.7 m/yr) was found at Mokuleia Beach. The percentage of accretion increased from 14% (for long-term rates) to 18% (for short-term rates). The maximum short-term accretion rate was found at the same location as the maximum rate in the long-term analysis (Puunoa Point at Lahaina).

Island of Hawaii

Northeast Hawaii Region

The Puna District comprises the eastern-most corner of the Big Island, reaching out at Cape Kumakahi, a broad rocky point with a shallow slope at the coast. North of Cape Kumukahi, the coast extends for roughly 25 km around Leleiwi Point into the Hilo District and Hilo Bay in a series of wave-weathered, low rocky sea cliffs, and rough remnant lava flows.

The Pepeʻekeo-Hämäkua Coast stretches for 100 km between Hilo and Waipiʻo Valley to the north. This northeast and northern exposed coastline consists of a steep rocky shoreline of Mauna Kea lavas, characterized by a

multitude of headlands, sea cliffs (~30–90 m high), coves, and irregular embayments such as Onomea, Hakalau, and Maulua Bays.

Waipi‘o Valley, in the far northeast, marks the junction where Mauna Kea lavas to the south overlie lavas of the broad and elliptical Kohala Volcano (1,670 m) to the north. The valleys such as Waimanu, Honopu‘e, Honokäne Nui/Iki, and Pololü are bordered by steeply ascending massive rock walls. Dynamic beaches dominated by black volcanic sand line the seaward end of the northeast Kohala valleys. Between the largest of the amphitheater valleys, the coast is dominated by blunt sea cliffs that rise to 400 m above the ocean.

Akoakoa Point lies north of Pololü Valley where the east Kohala coastline is made up of steep lava headlands and irregular low-lying, rocky embayments where streams enter the ocean out of wetland gulches. Like the shoreline to the south, small rocky sea stacks lie offshore of eastern Kohala, isolated from the retreating coast by heavy North Pacific surf.

West Hawaii Region

Kawaihae Harbor is the second deep-draft harbor on the Big Island and is fronted by a system of offshore fringing reefs. Several sand beaches exist at the south end of Kawaihae Bay, derived from eroded coral that was dredged during construction of the Harbor. Approximately 5 km south of Kawaihae lies Häpuna Beach, the widest of the few well-developed calcareous sand beaches on the Big Island.

Hualälai Volcano (2,521 m) makes up the central western coast of the Big Island. From the western banks of the shallow coastal lagoon at Kïholo Bay, the Hualälai coast extends southwest and is rocky and shallow sloped. Offshore fringing reef and pocket sandy beaches line the numerous embayments including Kakapa, Kua, and Mahai‘ula Bays along this coast.

Lavas of the most recent Hualälai eruptions make up the coast from the south side of Mahai‘ula Bay to the western tip of the Island at Keähole Point. The coastline of historic Hualälai lava extends fewer than 30 km south of Keähole Point, beyond Kailua-Kona to the small non-distinct west-facing Kuamo‘o Point. The South Kona district has a coastline rich with relics of historic Hawaiian habitation. Much of this coast is low-lying historic lava that has been gradually invaded by hardy vegetation. In

contrast, Kealakekua Bay is an area along this coast that contains steep cliff walls that reveal the layered nature of their basalt.

Because of its relative youth, the Mauna Loa coastal terrace of the southwest coast has lower degrees of soil development. The shoreline from Moiliʻi to Ka lae Point is made up of shallow and moderately sloped headlands and low sea cliffs and is backed by numerous wetlands areas fed by the underground freshwater flows. Beaches of the southwest coast are almost exclusively black sand.

Southeast Hawaii Region

Extending north from Ke lae Point, the southeast coast is made up of steep rocky headlands that transition to a low-lying coastal plain in the region of Honuʻapo Bay. Kïlauea Volcano is a large bulge on the southeast flanks of Mauna Loa. By late July 2002, two arms of flow had reached the ocean forming a broad lava delta that runs 570 m along the coast extending 50 m offshore of the West Highcastle coast, and a 1,540 ft-wide lava bench that extends more than 300 ft offshore at Wilipea. Lava benches may collapse suddenly into the ocean, leaving behind sharp cliffs and creating steam plumes of lava haze as seawater boils and vaporizes on contact with the rocks that may be hotter than 1,100 °C.

Recommendations

The Hawaii RSM PDTs have determined that the following recommendations are essential for maintaining stable beaches for public usage along the shores of the Hawaiian islands of interest (Kauai, Oahu, Maui, and Hawaii).

Island of Kauai, North Kauai Region

Hanalei River

Sediment has in-filled the river bed to the point where there is not enough capacity in the river bed to convey flood waters. Hanalei Town experiences flooding during significant rainfall events. Non-structural flood control may be warranted (hau tree and mangrove removal).

Black Pot Beach

Kauai County has two boat ramps at the mouth of the river. The ramps and the river mouth have the potential to clog with sediment.

Island of Kauai, East Kauai Region

Kapaa Beach

The federally authorized Kapaa Shore Protection Project groin (north of the Moikeha Canal) may be redirecting sand to the offshore. There is a need to investigate the project features and determine if re-nourishment is authorized.

Waikaea Canal boat ramp

The boat ramp was recently dredged, and Kauai County has stockpiled approximately 3,000 cy of beach quality sand for future re-nourishment of the adjacent shoreline.

Aliomanu Beach

Houses and road are currently threatened by shoreline erosion.

Wailua River

The State of Hawaii maintains sediment that accumulates at the river mouth. With consistent rainfall, sand that has accumulated at the mouth of the river would potentially be flushed oceanward. It is unclear what mechanism would bring the sand back to the shoreline. There does not appear to be adequate volumes at the river mouth to replenish the entire length of eroding shoreline. Historically there have been seasonal erosion problems at the river mouth.

Kealia Beach

Seasonal shifting of sand causes temporary shoreline erosion problems. There may be a way to implement the USACE Engineering With Nature (EWN) program strategies within the region.

Island of Kauai, South Kauai Region

Poipu Beach

Episodic shoreline retreat has been experienced. Kauai County is planning a small-scale beach nourishment project for Poipu Beach Park using washed sand from the Mana Plain. There are long-term plans for a larger beach nourishment project utilizing sand from offshore, but funding is

presently not available. Other areas in the region that would benefit greatly from beach nourishment are the beach in front of the Sheraton Hotel as well as Waiohai Beach.

Breneke Beach

Sand from the Mana Plain in west Kauai was used to nourish the beach. Much of the material has cemented. There is a need to investigate sand washing techniques and their effectiveness.

Kukuiula Harbor

The shoreline on the inside of the Harbor has been reclaimed from private ownership. The beach is scheduled to be nourished, at which time it will be turned over to Kauai County for management. RSM efforts should focus on identifying suitable sand sources. Mana Plain is one possible source.

Port Allen Harbor

The shoreline inside the Harbor is receding. A revetment was constructed to stabilize the shoreline, and there is presently no dry beach fronting the structure. Dredged material could be placed in the area or on the adjacent sandy shoreline.

Island of Kauai, West Kauai Region

Kikiaola Shallow Draft Harbor

This Harbor is the primary RSM challenge for POH at the present time. Sediment is intercepted by the east breakwater, entrance channel, access channel, and harbor basin. The down-drift shoreline is eroding. Sediment needs to be bypassed, the Harbor needs to be dredged, and a long-term RSM strategy needs to be developed.

Kekaha Beach

Currently, the State of Hawaii is constructing a pile dike north of the federally authorized revetment in an attempt to save the State highway from undermining.

Hanapepe River

Sediment is building up within the river alignment and increasing flood vulnerability.

Waimea River

Sediment is building up within the river alignment and increasing flood vulnerability. Removal of the sediment and its ultimate beneficial use could be facilitated by RSM and EWN. In general, stream clearing guidance needs to be developed for Kauai County to ensure that the sediment is beneficially used and that there are no adverse environmental impacts associated with its use.

Island of Kauai PDT RSM General Comments

The State of Hawaii, Department of Health (DOH), Clean Water Branch (CWB), issues water quality certifications for beach fill projects. Programmatic coordination with CWB regarding the goals of RSM, and regarding the importance of utilizing the State's valuable sediment resources, should be conducted to streamline the water quality certification process for RSM actions.

Stockpiling beach quality sand for future use as beach fill would be a worthwhile initiative.

Island of Oahu, North Oahu Region

Haleiwa Sub-region

Analysis of the impacts of the Haleiwa Small Boat Harbor Harbor on adjacent shorelines, and potential sand bypassing operations to restore the beach fronting the park, are yet to be conducted. Sand that accumulates on Alii Beach adjacent to the state-owned breakwater will be considered for bypassing. Currently, backpassing of sand along the park shoreline is not being conducted by the City and County of Honolulu (C&C) due to lack of permits to place the sediment in the water. The DOH and POH need to be consulted to secure permits to move sand from the accretional fillet to the eroding eastern shoreline.

Waialua Beach

Erosion threatens shoreline development along Waialua Beach Road.

Island of Oahu, East Oahu Region

Punaluu and Hauula

Shoreline recession threatens the highway in these areas. The State of Hawaii Department of Transportation (DOT) has dumped rock in certain locations in an attempt to stabilize the shoreline. Permanent solutions to the shoreline recession problems are being developed by DOT. Sediment management may be able to address a portion of the problem.

Kaaawa

There is an authorized Federal shore protection project at Kaaawa. The shoreline has receded to pre-project conditions and should be considered for nourishment.

Kaelepulu Stream

The C&C recently relocated approximately 6,000 cy of sand from the stream banks to above the mean high waterline along the shoreline. Coordination with DOH and POH Regulatory Division should be initiated to determine the necessary permit actions required to allow for the sand to be placed back into the littoral system.

Lanikai

An update of shoreline locations along Lanikai Beach would facilitate quantification of the need to implement the Lanikai Beach Restoration Pilot Project.

Bellow Air Force Station (AFS)

Removing the revetment at Bellow AFS or constructing a beach fill project seaward of the structure remains a top RSM priority on the Island of Oahu.

Island of Oahu, South Oahu Region

Kahala

Beach rock has been exposed along much of the beach in this region indicating active shoreline recession. The condition renders the beach face narrow and hazardous to beachgoers. Investigation of various options for restoring the beach should be developed.

Fort DeRussy

A multi-agency team is assisting Hale Koa Hotel staff in the development of a backpass plan for Fort DeRussy Beach. Sand that has accumulated at the west limit of the beach would be hauled to the eroding eastern shoreline.

Ala Moana Beach

The central portion of Ala Moana Beach has eroded back to the seawall. There is a need to redistribute the remaining sand in the area or bring in new material. Many areas of the beach have become rocky and unsuitable for typical beach activities.

Iroquois Point

A private development company is constructing nine T-head groins and is planning to place approximately 80,000 cy of beach quality sand along the development shoreline. A portion of the sand has been stockpiled from previous dredging operation for Pearl Harbor (approximately 20,000 cy). The balance of the material is also to come from Pearl Harbor channel dredging.

Island of Oahu, West Oahu Region

Mauna Lahilahi Beach Park

The C&C built a breakwater offshore of the beach park. The structure was placed too close to the shoreline, and the beach has responded negatively. Adjustment of the shoreline in response to the breakwater has exposed the revetment fronting the condominium. RSM principles could be utilized to reduce shoreline recession of the park property.

Pokai Bay

Erosion issues should be investigated in Pokai Bay. Impacts of navigation features on the Bay shoreline should be quantified.

Makaha Beach

Cyclical shoreline recession impacts Makaha Beach. Residents in the area moved sediment from the stream mouth to the northern limit of the beach in February 2011. The beach should be monitored to ensure that the stream mouth sediment is backpassed prior to the onset of critical recession.

Island of Oahu PDT RSM General Comments

The Island of Oahu Regional Sediment Management priorities include Haleiwa and Ala Moana beach parks.

Sediment management at stream mouths is a major RSM issue on the Island of Oahu.

Water quality certification is one of the major road blocks to effectively managing littoral sediments on the Island of Oahu. Routine maintenance of infrastructure at and near the shoreline is hampered by the lack of urgency provided by the DOH Clean Water Branch.

Island of Maui, North Maui Region

Kahului Deep Draft Harbor

The Harbor is scheduled to be dredged in FY15. Based on the quality of material to be dredged, there is a possibility the dredged material could be placed on Kanaha Beach east of the project area. There is a need to begin coordinating RSM activities in association with this dredging opportunity.

Baldwin Beach

There previously was extensive sand mining conducted at Baldwin Beach. The sub-region has a high shoreline retreat rate. This would be an informative RSM study area.

Manpokuji Bay

Shoreline property owners are proposing to build a revetment. The County of Maui would like the owners to consider soft solutions to the problem. The Bay is a littoral cell with no exchange of sediment around the headlands that make up the cell. Any fill that is placed within the cell would be relatively stable in the long term. This indicates favorable coastal processes for a soft solution versus hardening of the shoreline.

Sugar Cove

A recent beach nourishment project at Sugar Cove resulted in the placement of a few thousand cubic yards of sand and construction of three geotube groins. The Sugar Cove residents have applied for a permit to remove the three geotubes and replace them with rubble-mound groins. There is no additional beach fill being proposed. RSM investigations on the use of groins to induce shoreline stability are needed.

Island of Maui, Kihei Maui Region

North Kihei

The coastal road is threatened by shoreline retreat along a lengthy portion of North Kihei. The DOT's only solution for road protection is currently shoreline hardening (revetments, pile dikes, and dumped rock).

Kalama Beach

An existing POH revetment may be impacting the adjacent shoreline to the north. Flanking of the revetment is indicated by extensive shoreline recession which threatens a number of houses to the north. POH should investigate cause and effect of the federal project on the shoreline retreat.

Island of Maui, West Maui Region

Hololani

Temporary shore protection measures have been installed adjacent to a condominium in Hololani. The condominium association has requested a permit to remove the temporary features and harden the shoreline. Coastal engineering analyses provided by the association predict that a stable sand beach will accrete seaward of the structure.

Island of Maui PDT RSM General Comments

Sand is not recognized as a mineral by the State of Hawaii, and therefore neither its sale, use, nor transport is regulated by State or County policy.

Maui County needs to stockpile sand until such time that it can be used for beach nourishment.

Maui County staff recommended that lessons learned from the recent Waikiki Beach be documented and reviewed so they can be incorporated into future beach renourishment activities.

Maui County is processing an ever-increasing number of permits to harden shorelines. It feels that there is a need to develop alternatives to hardening since those types of alternatives remove beaches from the public domain.

Island of Hawaii, Northeast Hawaii Region

Waipio Valley

Large volumes of sediment were introduced into the Waipio Valley stream as a result of the 2006 earthquake. The stream mouth is typically plugged with sand, rock, rubble, and large basalt boulders. It is important to investigate inclusion of Waipio Valley as an Engineering With Nature (EWN) initiative. The Natural Resources Conservation Service has developed a stream maintenance plan to deal with various aspects of the problem. The plan addresses stream activities and the permits and approvals necessary to conduct stream maintenance activities for the protection of the property and livelihood of the residents of Waipio Valley. The plan also strives to help maintain aquatic habitat for native organisms and preserve the cultural heritage of the Waipio Valley.

Wailoa Boat Harbor

During a recent maintenance dredging of the Harbor, the dredged material was trucked from the site to unknown locations. Hawaii County staff would like to investigate putting the sediment dredged from the harbor along the adjacent shoreline.

Hilo Harbor

Modification of the breakwater is recommended by County staff to improve circulation and ultimately water quality within the Bay. Future deepening of various channels and berthing areas in Hilo Harbor are being considered. POH plans to conduct maintenance dredging at all deep-draft harbors in the State that are below project depth in FY15. Material dredged during these and other operations should be considered for beneficial use.

Island of Hawaii, West Hawaii Region

Puako Boat Ramp

County staff indicated that there are sediment shoaling problems being experienced at the ramp.

Kawaihae Deep Draft Harbor

POH plans to conduct maintenance dredging at all deep-draft harbors in Hawaii in FY15. Material dredged during this and other operations should be considered for beneficial use.

Pelekane Bay

A major decline in the abundance of the marine biota has taken place. Possible causes of this deleterious change were associated with long-term sedimentation due to terrestrial runoff from the Kawaihae watershed and reduced ocean circulation in Pelekane Bay caused by construction of the deep- and shallow-draft harbors. County staff feels that further investigation of sedimentation issues at Pelekane Bay is warranted.

Island of Hawaii, Southeast Hawaii Region

Punaluu County Beach Park

County staff has concerns about the stability of the black sand beach located within the beach park property.

Hawaii Regional Sediment Management (RSM) Priorities

The Hawaii Regional Sediment Management (RSM) Project Delivery Team (PDT) has identified opportunities to manage coastal sediments on a regional scale throughout the main Hawaiian Islands (Kauai, Oahu, Maui,

and Island of Hawaii). The PDT consists of U.S. Army Engineer District, Honolulu (POH) staff; the State of Hawaii Department of Land and Natural Resources, Office of Conservation and Coastal Lands; County staff; and various stakeholders. The PDT has a comprehensive understanding of RSM needs throughout each County, and the State as a whole. An island-by-island prioritization of RSM initiatives has been conducted. This document provides direction on development of future Hawaii RSM studies and evaluations.

The following is an island-by-island listing of USACE RSM priorities in the State of Hawaii and a strategy to maximize beneficial use opportunities.

- Island of Kauai (Kauai County)
    - Kekaha Region
    - Kapaa Region
    - Poipu Region–The Poipu region has previously been studied by the Hawaii RSM initiative. Kauai County is planning a small beach nourishment project for a portion of the Poipu shoreline and considers it to be a priority RSM region.
    - Implementation of RSM Principles–Kauai County seeks to shorten permitting timelines for State water quality certification and desires to investigate the logistics of stockpiling beach quality sand for future renourishment activities.
- Island of Oahu (City and County of Honolulu)
    - Haleiwa Region
    - Ala Moana Region
    - Implementation of RSM Principles–The City and County of Honolulu seek to improve stream mouth clearing operations and attain programmatic permitting of beach placement of stream sediment.
- Island of Maui (Maui County)
    - West Maui Region (Kaanapali through Honolua Bay)
    - Kihei Region
    - Kahului Region

  - Implementation of RSM Principles–Maui County seeks to investigate logistics of stockpiling beach quality sand for future renourishment actions and to develop ways of implementing soft solutions to beach erosion rather than hard solutions that remove coastal shorelines from the public domain.

- Island of Hawaii (Hawaii County)

  - Waipio Valley Region
  - Hilo Bay Region
  - Kawaihae Region

- Hawaii RSM PDT Strategy to Maximize Beneficial Use Opportunities– The U.S. Army Engineer District, Honolulu, Hawaii, plans to conduct maintenance dredging at the following harbors in Fiscal Year 2015 that will result in an estimated total volume of 280,000 cy of material. It is a strategy of the Hawaii RSM PDT to maximize beneficial use of this material, with the recognition that early coordination and identification of implementable RSM actions will be vital to the ultimate success of this initiative.

Harbor	Volume (cy)
Barbers Point Deep Draft Harbor	16,000
Kahului Deep Draft Harbor	86,000
Hilo Deep Draft Harbor	51,000
Honolulu Deep Draft Harbor	80,000
Nawiliwili Deep Draft Harbor	47,000
Total Volume	280,000

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14. ABSTRACT
Regional Sediment Management (RSM) refers to the effective use of littoral, estuarine, and riverine sediment resources in an environmentally sensitive and economically efficient manner. RSM was officially implemented at the U.S. Army Engineer District, Honolulu, Hawaii (POH), in February 2004. The overall POH RSM strategy is to investigate RSM opportunities along all coastal regions in Hawaii. Opportunities to implement RSM activities are documented and prioritized by island based on input from the Hawaii RSM Project Delivery Team (PDT) consisting of POH staff; the State of Hawaii Department of Land and Natural Resources, Office of Conservation and Coastal Lands; County staff; and various stakeholders. The U.S. Geological Survey (USGS) also recognizes that beach erosion is a chronic problem along most open-ocean shores. USGS has contracted with the University of Hawaii (UH) at Manoa, Coastal Geology Group (CGG), to conduct an assessment of shoreline change on three of the main Hawaiian Islands (Kauai, Oahu, and Maui). Because of the inherent critical interest of these three coastal sediment aligned organizations (USACE, USGS, and UH CGG), research conclusions by these agencies regarding sedimentation along the coastlines of the Hawaiian Islands of interest are incorporated into this document. Permission of USGS to reproduce verbatim pertinent text, tables, and figures regarding Kauai, Oahu, and Maui is acknowledged with appreciation. Pertinent sections from the UH CGG website pertaining to the Island of Hawaii are also extracted verbatim by permission which also is acknowledged with appreciation. Shoreline change rates were calculated from long-term and short-term shoreline data. A minimum of three historical shoreline positions was required when calculating the shoreline change rate. An island-by-island prioritization of RSM initiatives has been conducted by the Hawaii RSM PDT, along with a strategy to maximize beneficial use opportunities.

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